B.I.O.S. FINAL REPORT No. 1289

ITEM Nos. 35

# GERMAN DRAWING INSTRUMENT INDUSTRY



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BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

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LONDON—H.M. STATIONERY OFFICE

Your attention is drawn to the existence of B.I.O.S. Information Section, 37 Bryanston Square, London, W.1, to which enquiries about German Technical Processes, etc., covered in B.I.O.S. Reports, and requests for German Technical Information otherwise available in the U.K. can be sent.

# GERMAN DRAWING INSTRUMENT INDUSTRY

REPORTED BY

W.A.D. STARK, M. of S.

B.I.O.S. TRIP No. 1976

INSTRUMENT PANEL, MINISTRY OF SUPPLY

B.I.O.S. Target Numbers
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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE,
32, Bryanston Square,
London, W.1.

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SECTION 1.

Report by B.I.O.S. Trip No. 1976.

Duration of Trip:- 12th March, to 6th April, 1946.

Personnel of the Team:-

Leader, Mr. W. Stark - Ministry of Supply D.I.P.
Mr. W. Berg
Mr. M. Leuba
Mr. F. McCarthy

This report is produced in collaboration with B.I.O.S. trip No. 2099 who also visited the majority of the firms which are reviewed in this report.

Personnel of team:-

Leader, F. Boxall
F.S. Million
D. Ward

SECTION 2.

Introduction:- The object of this investigation was to enable the British manufacturers of drawing instruments, slide rules and mathematical scales to study the methods and conditions of the manufacture of these instruments in Germany, in addition a visit was also made to the manufacturers of dividing machinery. The investigation was considered of importance to the trade in this country in view of the very severe competition met from this source for many years prior to 1939. This competition was encountered in the British Isles, and also in the export markets of the British Empire and other countries. In the supply of drawing instruments and slide rules, German products, covered a complete range from the highest to the lowest quality. Their total output of these instruments was colossal compared with the output of this country, and it was generally recognised that Germany supplied the majority of the world's requirements. They also enjoyed, generally speaking, an advantage in price over this country, and had a world-wide reputation on the higher quality products.

The investigation was planned to cover all known existing manufacturers in the British, American and French-occupied zones of Germany, and this was achieved, with the exception of a few small firms. Special interest was given, when planning the trip, to concentrate on the methods of manufacture of the better quality instruments, and it is rather interesting to note that all the firms except one were engaged on good quality instruments and slide rules.

Firms Visited:- The following is list of firms visited and type of products manufactured:-

| Firm | Location | Zone | Products |
|---|---|---|---|
| Johann Lotter | Wilhelmsdorf | - U.S. | Drawing Instruments, (Full range) |
| Lotter & Co. | Neustadt | - U.S. | Drawing Instruments, (Medium quality) |
| Hermann Kraft | Neustadt | - U.S. | Drawing Instruments, (School quality) |
| Christof Birk | Neustadt | - U.S. | Drawing Instruments, (Good quality) |
| BayerischeReisszeugfabrik A.G. | Nuremberg | - U.S. | Drawing Instruments, (Full range) also Slide rules and Scales. |

| Firm | Location | Zone | Products |
|---|---|---|---|
| A.W. Faber Castell | Geroldsgrum | - U.S. | Slide Rules, Scales, Rulers. |
| Geo Kessel | Kempten | - U.S. | Dividing and Engraving machinery. |
| A. Ott. | Kempten | - U.S. | Planimeters. |
| Clemens Riefler | Nesselwang | - U.S. | Drawing Instruments, (Good Quality) |
| Gebruder Hoff | Pfronten-Reid | - U.S. | Drawing Instruments (Good Quality) also Planimeters. |
| Mayr and Hormann | Pfronten-Steinach | - U.S. | Drawing Instruments, (Good Quality) Planimeters, Proportional Compasses |
| J. Rumold | Zuffenhausen Stuttgart | - U.S. | Mathematical Scales, Rulers. |
| Albert Nestler A.G. | Lahr, Baden | - French | Slide Rules, Scales, Rulers, Drafting Machines. |
| Rudolf Nestler | Lahr, Baden | - French | Drawing Instruments (Good Quality) |
| Dennert and Pape | Hamburg | - British | Slide Rules, Rulers, Scales Planimeters. |

Present Output:- The combined output of the factories visited would appear to be very much in excess of the output of this country at the present time, especially in the case of slide rules, and here it must be observed that one of the largest slide rule manufacturers, Albert Nestler, is not in production at present, but will probably recommence in June, 1946, if given facilities by the French Military Government.

The factories visited were only working to approximately 50% of their pre-war production rate, this being due mainly to the following reasons:-

(1) Lack of raw material.
(2) Insufficient fuel and power.
(3) Shortage of labour.
(4) In a small proportion, to the effects of damage sustained by action during the war.

There seems no lack of orders at any of the firms visited, and it was noticed that firms in the British and U.S. zones were trying to build up on their present output.

Condition of Labour:- The industry is working a 5-day week of between 40 to 48 hours, and the rates of pay of the employees range from 50 pfennigs per hour to 1 mark 50 pfennigs for the very highest skilled workman. The higher rates of pay obviously apply to the firms in the bigger cities. These rates show very little increase to the pre-war rates.

Raw Materials for Drawing Instruments:- There is a general shortage of German silver, as the source of supply was in the area now controlled by the Russians, and, therefore, apart from small stocks which the firms may still have, all instruments produced to-day are in brass.

Screws and Small Steel Turnings were previously supplied to the majority of manufacturers by Switzerland, some stocks still seem to be in existence, although the German manufacturers are now getting rather anxious to obtain further supplies from Switzerland, as they consider that the German article is not so good or so cheap. Only a few firms have anodes for plating, and the greater majority of brass instruments are being supplied unplated.

Raw Materials for Slide Rules and Scales, etc. Apparently, Germany has not imported sufficient hardwood for many years, and the manufacturers have turned over to local grown woods, which seem to be in good supply. The local grown woods now in use are Maple and Pearwood. Some stocks of mahogany are held by the larger firms.

Costing:- The price of the finished article has not risen by more than 10% to 15% over 1939 in any of the firms visited. This was probably due to the fact that wages were stabilised in 1938 and have not been altered since, and also to the efficient methods of

manufacture, which, generally speaking, lead to higher output per man hours. Furthermore, factories were well laid out with good tooling, and in many factories, some very ingenious machines and jigs were in use. The discipline and skill of the German worker must also be taken into account, and the general impression gained by the party was that the German employee was of a very industrious nature, and seemed to require very little supervision or inspection of work.

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The information contained in the following reports is based on that given to the Party by the persons interviewed at the various firms. Every effort was made to check this and we consider all facts and figures contained herein to be reasonably accurate.

SECTION 3.

REPORT ON.

| | |
|---|---|
| Firm: | A.W. Faber-Castell. |
| Location: | Geroldsgrun (Naila). |
| Person Interviewed: | Mr. Bülow. |
| Number of Employees: | 220 Men.<br>45 Women. |
| Rates of Pay: | 75pf. per hour. |
| Hours: | 48 hours per week; five days. |

Description of Firm and Products.

This firm is world renowned for the manufacture of slide-rules, for which it had international sales. The range of instruments now produced consists of a comprehensive range of slide rules, mathematical scales, and rules of various types.

The output of slide rules by this factory is tremendous, and in pre-war days probably exceeded even that of Albert Nestler. The quality of the products is still extremely high.

The factory described in this report is occupied exclusively on the manufacture of slide rules, mathematical scales and rules, but in addition to these premises, the firm has other branches elsewhere in Germany, where entirely different types of articles such as pencils etc., are manufactured.

The factory at Geroldsgrun is situated in a comparatively small village in the heart of rural surroundings. It consists of a large group of modern buildings capable of accommodating 600 employees. None of these buildings has received war damage, and the firm's equipment is intact. The factory is completely self contained, having its own electrical generating station, saw mills, drying rooms for seasoning of timber, fully equipped tool making and maintenance shop, and is fully mechanised to deal with the manufacture of all types of rules.

Products are manufactured in every stage from the cutting of the raw timber to the completely finished article. It is obvious that the plant has been pre-planned, and laid out in the most efficient manner. Wherever possible hand operations are dispensed

with, and special purpose machinery introduced. Great care is given to the seasoning of timber, and the machining of the wood is done to very precise limits. Despite this mechanisation, a high degree of craftsmenship is still necessary, in certain operations. It is of extreme interest to note that all standard types of slide rules, scales and rules are graduated and figured by a hot pressing process, and not by machine dividing.

Methods of Manufacturing Slide Rules.

The timber chiefly used in local grown maple wood. After rough cutting and seasoning, the precise machining is done by a series of operations on horizontal milling machines, each machine being set up specially for one operation. Fine tooth milling cutters specially shaped are used, and the work fed into the machines by continuous chain band. Before assembling the various sections of the rule, steel spring inserts are embossed into the base, and the other sections assembled over this. The next stage is to fit the celluloid facing to the body and slide. It is interesting to note that the surface of the celluloid which holds the adhesive is scored by hand, while practically all other work is done by machinery. The firm considered this hand method is the quickest and most efficient method of cutting the diagonal cross grain required to carry the adhesive which bonds the celluloid to the wood base. The method of cutting this grain is as follows: Sheets of white celluloid about 20" x 30" are placed flat on a bench and scored, diagonally in each direction, with a type of carpenter's smoothing plane, the iron blade having saw-like teeth, about 1/26" pitch. This produces a finish on the celluloid with an undercut feathered score, which when loaded with glue, is placed on the wooden rule body under pressure, and maintained in clamps until dry for six months. This gives a remarkably strong joint between the celluloid and the wood, so much so, that Faber's have given up the practice of dowelling at each end of the rule, which in the past was done to stop shrinkage of the celluloid facings.

All glued surfaces whether wood to wood, or wood to celluloid are placed in clamps for a period of not less than six months.

Thus some idea can be gained of the number of clamps and space necessary for the production of slide rules, which pre-war totalled 1,000,000 per annum. It is estimated that the time taken to complete a rule from start to finish covers a period of 18-24 months.

When the slide has been fitted to the body the complete assembly is passed through a milling machine once again, in order to trim the thickness of the rule down to a standard measurement. The tolerance allowed at this final trimming operation is 5/1000". The base of the rule is finally slit down the centre leaving the base in two parts, which are held together by the steel springs, which have been inserted at an earlier stage of assembly. This slitting operation however is not done until after the graduating operation, so that the body of the rule remains solid and rigid for the hot pressing process, used to mark the graduations.

Graduating and Figuring.

This is done by a hot pressing process, on a battery of hand operated presses, the master-die for marking being heated and the temperature thermostatically controlled to maintain an even heat, the time cycle for the full line impression including all numbering and lettering being four seconds per rule. The graduating of the face is done in one operation with the slide inserted into the body. Afterwards, the slide is removed and the reverse side graduated in a similar manner. The filling in various colours is done by hand, and the final sandpapering, to remove the burr raised by the pressing is also a hand operation.

Master Dies for Slide Rules.

The construction of the dies used in this process are of special interest, and are made at the factory in the following manner.

A blank matrix of hard rolled brass in approximately one inch square section, and of appropriate length is recessed by a series of saw cuts, the spacing between each saw cut representing the spacing of the graduations of the intended scale. The machine used for this operation is of simple design, a horizontal table having a traverse sufficient to accommodate a 20" rule. The traverse is controlled by the use of an accurate lead screw and nut, being suitably geared to a dividing head, with a plate divided to suit any scale that is being cut. Provision is made to eliminate any back-lash. Mounted at the back of the horizontal table is a cross slide with power feed transmitted to the slitting saw head, which overhangs the table at right angles. The saw used is approximately 2½" in diameter by .003" wide. This cuts a slot into the brass matrix, dead on size, giving a nice push fit to the .003" thick steel inserts, each one of which is pressed home before the saw cutting the next slot. After the insertion of all the blades, the brass dividing wall between each blade is lightly punched with a flat ended chisel to ensure that

they are held firm. The next operation is to drill suitable holes through the face of the brass block and insert the number of letter required.

The manufacture of the impression dies calls for considerable patience and experience by the craftsman. On 1 10" standard slide rule having seven scales, there are 2,500 individual lines, and approximately 300 numerals and letters. Therefore if any error is made in slotting or recessing, there is very little margin to rectify it. These impression dies are very costly to produce, but are well worth the trouble in that they save a tremendous amount of time in the subsequent method of graduating the rule. The master impression dies give an extremely clean and definite line of consistant width. This method of graduating appears to be very efficient, and could well be recommended to the English manufacturer.

Mathematical Scales. Triangular Section - Celluloid Faced.

These are made from either maple or pearwood. They are machined to shape on a spindle moulding machine, the surface being scored in the machining in order to accept and retain the celluloid facing. The celluloid is scored in a similar manner as that described in the manufacture of slide rules, and an adhesive of animal glue emulsion is used. The rules are then placed individually into clamps and left to dry.

Oval Section Scales.

These also are made from maple or pearwood, and it is noticed that a certain amount of handwork is done in laying the celluloid face and scraping down to shape, prior to dividing.

Machine Dividing of Mathematical Scales, Triangular, and Oval Sections.

This is done on straight line dividing machines, the Dividing Shop containing the following machines.

2 Automatic dividing machines, each having eight cutting heads.
2 " " " " " six " "
1 Dividing machine hand operated, one cutting head.

These machines are set up by one man who is also responsible for loading and unloading, but it is possible he would need additional help to keep all machines fully employed. The machines used were manufactured by Messrs. Alfred J. Amsler, Schaffhausen, Switzerland.

Rulers.

An extensive range of rulers is manufactured, the majority of them appear to be faced with white celluloid, and graduated by the hot press method.

Finishing.

An elaborate spraying plant has been installed and rulers, scales etc. are sprayed with a high gloss cellulose varnish.

Output.

Pre-war the firms output of all types of slide rules totalled approximately 1,000,000 per annum. Present output is 10,000 to 11,000 per month, and in addition large quantities of rules, and mathematical scales areproduced.

Price.

The 10" slide Rule varies from 9.60 mks. to 14.40 mks. retail, according to type. The 20" slide rule from 17.20 mks. to 40 mks. retail. These prices have not increased more than 15% over 1939 prices.

Observations.

The potential output of this factory alone would appear to be in excess of Germany's normal domestic requirement for slide rules. At the present rates of exchange, the firm could undersell possibly any other firm in the world, and most certainly any firm in Britain. The quality and range of these rules leaves very little to be desired. Manufacturing methods, lay out of factory and equipment in addition to cheap labour, highly skilled, and locally produced materials result in the firm being able to produce high quality articles at comparatively low prices.

SECTION 4.

REPORT ON

FIRM: Albert Nestler, A.G.

LOCATION: Lahr (Baden) French Zone.

PERSONS INTERVIEWED: Mr. A. Nestler.

NUMBER OF EMPLOYEES: 90 at present; 600 pre-war.

RATES OF PAY: 90 pfennigs per hour.

DESCRIPTION OF FIRM AND PRODUCTS:

This firm has a world-wide reputation and sales for the highest quality slide rules and mathematical scales. It also manufactures draughting machines and tables and draughtsmen's accessories. The factory is a modern, well-lighted one with a floor space of at least 80,000 square feet, of which approximately one-third has sustained damage by bombing. The damage is mainly confined to the woodworking plant. At present, work is in progress repairing this, and all work is being done by staff of the firm. Despite the loss of some equipment in the woodworking plant, Mr. Nestler is convinced that the firm will be in working condition by June, 1946. At present, the only work in progress, apart from repairs, is the finishing of some small quantity of the stock of rules already fabricated before the bombing. It is estimated that stocks of approximately 200,000 slide rules are in an advanced stage of manufacture, and, in addition, there are also large stocks of partially completed mathematical scales, rules, draughting machines, etc. The party considers that when the plant is in full production, it is capable of producing a greater quantity of high grade machine-divided slide rules and mathematical scales than any other plant in either Germany or England. This large output is due to a great extent to the very original design of the automatic dividing machinery, which is installed in the dividing shop.

DESCRIPTION OF FACTORY AND PLANT:

Manufacturing Details:

Under the prevailing circumstances, it was not possible to obtain full details of manufacturing processes, but the following points are considered to be of interest:

The slide rules are of orthodox construction, the timber used being mahogany, and the facings being celluloid. The dividing is done on automatic straight line dividing machines, and the figuring is done by a hot pressing method. The filling of the dividing is a hand process, no special skill or equipment being necessary other than a stencil type brush, which is used to rub in

the oil bound black, green or red pigment. All excess filling is removed by rubbing the surface of the rule with fine wood dust.

The final surface polishing is done by the conventional rotating cloth mop, the operator holding the workpiece by hand against the underside of the mop during this operation.

Machine Shop:

A large, fully equipped machine shop capable of manufacturing and repairing medium and light machine tools; here it is claimed that all the firm's special purpose machinery, including the automatic dividing machines, were made, and it certainly seemed that this claim is fully justified.

Woodworking Plant:

This is a part of the factory which has sustained damage from bombing, but some equipment such as band saws, circular saws, spindle-moulding machines and special purpose milling machines, clamping and drying machines also specially constructed gluing apparatus, have all been salvaged and are now in working condition. It should now be possible to operate this plant on modified output when the building structure has been fully repaired.

Dividing Shop:

The dividing machines are as follows:-

7 Automatic Logarithmic Straight Line Dividing Machines used for dividing slide rules, each machine having 16 dividing heads.

7 Automatic Straight Line Dividing Machines for the dividing of mathematical scales of equal calibrations; all these machines are capable of dividing 36 scales of 30 cm. length at one time.

1 Circular Dividing Machine with 24 Face Plates, taking circular protractors up to 6" in diameter and dividing 24 protractors at one time.

1 Automatic Dividing Machine for dividing scales up to 3'11" in length.

Finishing Shop:-

The following is a list of machinery used on the finishing of the slide rules and mathematical scales. It will be noticed that many of them are of an automatic type, thus eliminating much

handwork:-

8 Automatic Sandpapering Machines, each having 12 working heads. This machine is used for rubbing down the face of the slide rules after dividing and filling.

1 Double-sided Buffing Machine for polishing mathematical scales in either triangular or oval section.

A Battery of Polishing Mops set up in rows on a long low bench where operators can sit during work. There is nothing unusual about their polishing methods.

The automatic sandpapering machines for the finishing of scales and rules is undoubtably of unique design.

These machines are extremely light in construction but sufficiently rigid for their purpose. Each machine has eight work heads which are operated by a double pantograph movement, the work head carries a fixture into which is clamped a length of sandpaper approximately six inches long by an inch wide. The sandpaper is fed from a roll contained on a reel at the base of the machine, when the abrasive surface shows signs of wear, the operator pulls the strip until an entirely new surface appears.

The work table is horizontal, and a light spring loaded clamping arrangement to hold the rule during surfacing operation.

Provision is also made to oscillate the width of the scale or rule underneath the abrasive paper thus ensuring a reasonably flat and parallel surface.

Dividing Machines:

All the automatic dividing machines are based on a general design which has been drawn up to a design originated by the present proprietor's father 20 years ago. The general design has been adapted to meet the special requirements of dividing the slide rules, scales, protractors, etc. but basically the design is similar. The following is a general description of the principle involved:-

The machine table is actuated by means of a heavy lead screw and nut, which are operated through a gear box by a cast iron drum, having a spiral cut on the outside. This spiral is notched at spacings corresponding to the logarithmic line required. A swinging lever, carrying a pawl, moves this drum and with it the lead screw, at each movement of the cutter head. The speed of working is about 60-70 stroke per minute.

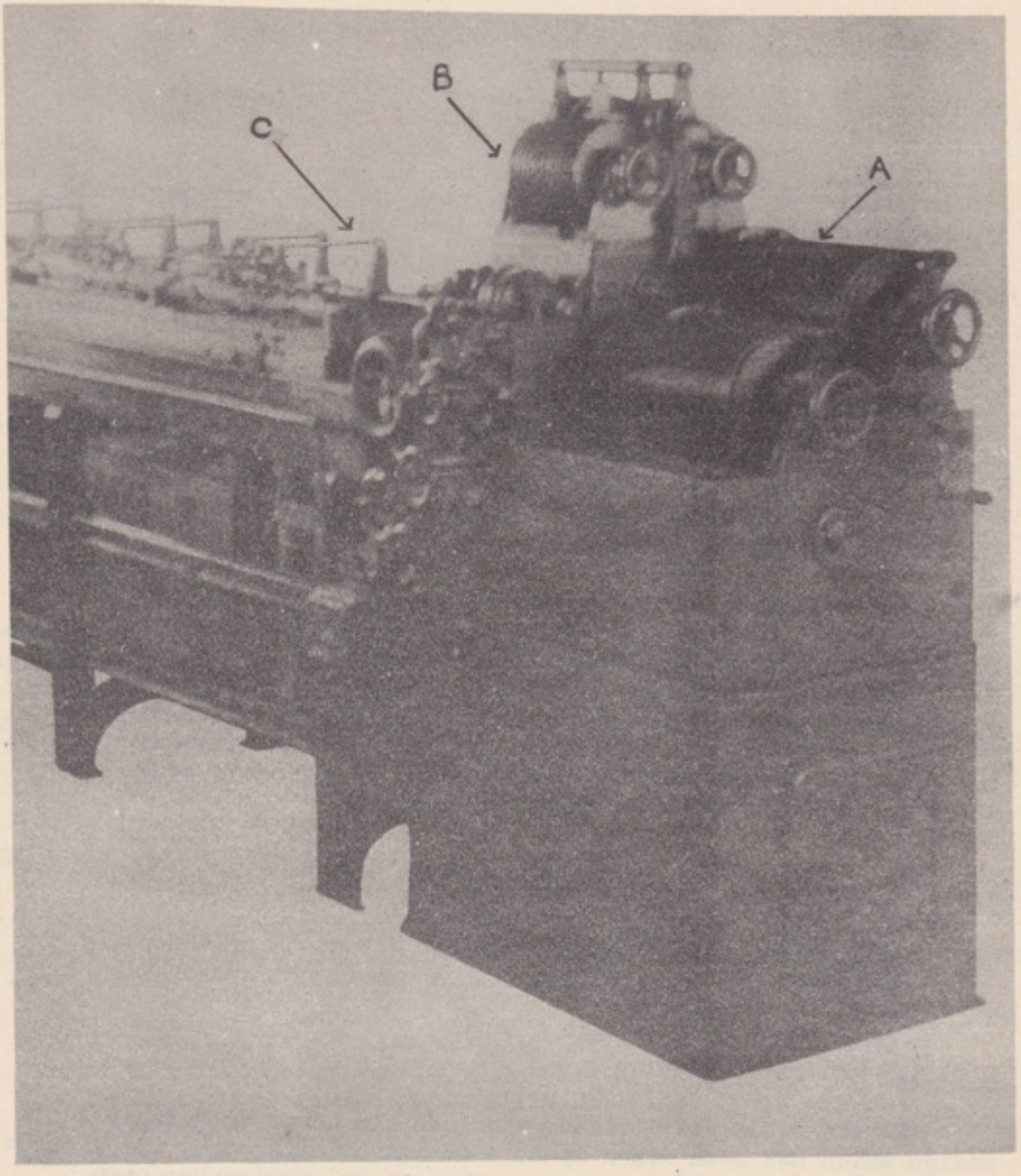



Illustration No: 1.

The illustration No.1 shows Nestler's Automatic Straight - Line Dividing Machine Head.

A. Drums to control the spacing of the graduation lines.
B. Drums to control the length of the graduation line.
C. The arm which connects one of the sixteen cutting heads.

Conclusions:

It is felt that fuller investigation of this firm should be carried out when the factory is in full production. No doubt, there is much of interest to the British Manufacturer concerning operations which are quite unique, such as the design and construction of the automatic dividing machinery, as in the opinion of the party, there is nothing in this country similar, and the machinery certainly shows great advantage over known existing machinery in this country.

SECTION 5.

REPORT ON.

| | |
|---|---|
| Firm: | Dennert & Pape |
| Location: | Hamburg, British Zone. |
| Person Interviewed: | Mr. Dennert |
| Number of Employees: | 130 |
| Rates of Pay: | 1 Mk. per hour (average)<br>Highly skilled men up to 1 Mk. 40 Pf. per hour. |
| Hours: | 48 hours per week. |

Description of Firm & Products.

This old-established firm has manufactured a range of mathematical and surveying instruments since 1848, and they claim to be the oldest makers of Slide Rules in Germany, having produced them since 1878. At the time of our investigation they were employed on the manufacture of a range of good quality instruments as follows:-

| | |
|---|---|
| SECTION I. | Slide-Rules in white plastic.<br>Mathematical Scales, various sections in white plastic.<br>Protractors, circular, semi-circular, etc. in transparent plastic.<br>Set Squares, various types in transparent plastic.<br>Rules, in transparent and white plastic. |
| SECTION II | Planimeters.<br>Surveying Levels.<br>" Theodolites<br>Cigarette Boxes in plastic. |

For the purpose of our investigation we were concerned only with the products included in Section I of the list. Of this section, the slide-rules are the most important in order of production. In addition to the standard type of 10" and 20" rules, the firm make many special purpose rules, for Electricians, Surveyors, Merchants, Engineers, etc. It is of especial interest that the firm make the rules entirely from plastic, the rule being machined from sheet material. The material used is of German manufacture supplied by Dynamit, A.G. Troisdorf, Cologne, and sold under the trade name of "Astralon". This material has been used

in manufacture of the rules over a period of 10 years or more, and it seems that the claims made for its normal stability have been proved to a great extent, in view of the exclusive use of this material for all Slide-rules and mathematical scales.

The other instruments listed in Section I are all machined from sheet plastic Protractors, Set Squares, etc. in the transparent material called Flexiglass, this being produced by Rohm & Haas of Darmstadt.

The trade mark of Dennert & Pape is "Aristo" and all plastic instruments are sold under the name.

The factory is situated within a mile or so of the centre of Hamburg; it consists of a group of old-fashioned buildings on three floors, and has an approximate total floor-space of 20,000 sq. ft. Owing to the rambling construction of the buildings, the space is split up into comparatively small shops. There is some superficial war damage to the factory, but it has not affected production to any evident degree. The equipment is in good condition, and adequate to produce the type of instruments in which the firm specialise.

This firm is turning out a fair quantity of good quality instruments. Their output is restricted through lack of labour, otherwise, in the opinion of Mr. Dennert, the production could be increased very considerably.

General Equipment.

This factory is well equipped for light engineering, and has a separate tool-making shop, employing 7 men, an apprentice shop, where 20 apprentices are being trained, a small drawing office, case-making shop, sand blasting and enamelling department, dividing machinery and Hot Presses.

Details of Manufacture, Slide-Rules.

Machinery.

The Rules are machined from "Astralon" a sheet plastic. All the operations in making the rule, preparatory to marking, are carried out on single-toolshaping machines. The operations include cutting from sheet grooving, slotting for the slide, bevelling edge of rule, and shaping of the slide. The assembly of the rule and slide is by selective fitting, some small amount of handwork being necessary in fitting the parts together. All the machining on the slide-rules is done on a battery of seven shaping machines,

each being set up for a single operation. After machining, the rules are allowed to season for a period of several months, before being graduated and figured.

Marking.

All marking on the standard types of Slide Rule, is done by a Hot Press process in which an electrically heated die is pressed into the surface of the rule, special rules (in small quantities) only being machine divided.

The dies used in the Hot Press process are made by the firm in the following manner. A blank die is recessed by a series of circular saw cuts on a milling machine, fitted with a fine micrometer adjustment lead screw. Into those recesses thin steel strips are fitted, each steel strip representing a graduation line of the slide rule.

Figuring and longitudinal lines are also set up and embossed by Hot Press methods.

It was noticed that for some of the cheaper type of rules a metal casting has been made from a matrix of the original die, and the casting was being used instead of the original die. The life of these castings was stated to be 5000 impressions.

Machine Dividing.

Special Slide Rules and Scales of which small quantities only are required are graduated by a dividing machine. For this work, the firm has three straight line dividing machines, with multiple head, hand operated, following a master scale by microscope.

Filling and Polishing.

The filling is in two colours, one being allowed to dry, before application of the second colour. The rules are then rubbed down by hand and finally mop-polished.

Details of Manufacture.

Scales and graduated Rules, Set Squares, Protractors.

These are produced on both "Astralon" (white opaque) and Flexiglass (transparent) materials, the machining of blanks being done by similar method to that described for Slide Rules. They are marked by the Hot Press process, the black and red filling being done by the laying on of pigmented strips. This pigmented material appears similar to typewriting carbon paper. It is cut to suitable

size and used only once. The die is first pressed into the rule or scale, and after impression the pigmented strip are laid in position and a second pressing is done. These operations are carried out while the rule or scale remains in the press. Finally they are polished by mop. Some machine dividing is done on special scale rules, etc.

Output.

The firm is producing 1500 slide rules per month with facilities to produce three times this quantity if allowed labour and materials. In addition some thousands of scales, graduated rules, set squares and protractors are made each month.

Price.

| | | |
|---|---|---|
| Retail prices of Slide Rules | 20" | - 28 Mks. 50 Pfs. |
| | 10" | - 14 Mks. 50 Pfs. |
| | 5" | - 7 Mks. 30 Pfs. |

These prices are a 10% advance on pre-war.

Observations.

The white plastic slide rules are of particular interest. The appearance is very pleasing, the graduating lines being slightly coarse, but very clear. The movement of the slide is smooth, relying for fit, entirely on quality of machining, and perhaps to one extent on the springiness of the material, there being no metal springs inset. The coincidence of lines of slide and stock is accurate. It is claimed that material used is stable under normal conditions of temperature and humidity.

SECTION 6.

REPORT ON

**Firm:** Gebrüder Haff.

**Location:** Pfronten-Ried, Nr. Kempten, Bavaria, U.S.Zone.

**Person Interviewed:** Mr. Haff.

**Number of Employees at time of visit:** 120 the majority of these were men

**Number of Employees pre-war:** 300

**Rates of Pay:** 76Pf - 90Pf. per hour for men.
50Pf - 76Pf. per hour for women.

**Hours:** 40 per week of five days.

**Description of Firm & Products:**

This firm has been established over 100 years and specialises in the manufacture of the following instruments:-

(a) A complete range of drawing instruments from the highest quality to school quality machine made instruments.

(b) A range of Planimeters comprising Polar and Compensating types.

(c) Protractors of varying types from full circular protractors made of German silver and graduated to half degree or quarter degree; also semi-circular protractors made of German silver and graduated to half degree or quarter degree. All these have a micrometer adjustment and being machine divided.

(d) Proportional compasses of varying types.

(e) Beam compasses of good quality having graduated steel beam.

The factory consists of a block of modern buildings having an approximate floor space of 30,000 to 40,000 sq. ft. The factory has obviously been specially built and equipped to manufacture these instruments under ideal conditions. It is situated in a small village about 20 miles from the nearby town of Kempten. The premises had suffered no war damage. All labour is drawn from the locality, the majority of the workers being trained from youth. An apprentice scheme is in operation whereby youths are given a 3½ years course in a specially equipped workshop, where they have a theoretical training in addition to a practical training before

being sent into the factory. It is customary for some of the firm's employees to work only during the winter months at the factory and during the rest of the year to be employed on agricultural work. This practice seemed to be satisfactory to both employer and employee, and no doubt gives the firm a certain flexibility in organising its labour force which are drawn from the rather limited local population. At the time of our visit the factory was working to about one third of its pre-war output. The reasons given for this by Mr. Haff were lack of raw materials and fuel and also in some measure to the fact that they were engaged upon the manufacture of Precision Padlocks and Door locks for the U.S. Forces.

Apart from the factory referred to in this report we were informed that the firm had another small factory in the locality for the production of the instrument cases.

Description of Equipment:

The equipment consists of first class milling and drilling machinery, dividing machinery for circular and straight line dividing, Finishing and Polishing Department, Platinf Department, Tool making and Maintenance Department.

Details of Manufacture:

The form of stock used for the compass limbs is flat bar with round edges, supplied to the firm in either brass or German silver. Machining is done on standard types of light milling and drilling machines, the holding fixtures and jigs being made on the premises.

The jigs and fixtures are particularly well made and finished but design features are not outstanding, much being left to the ingenuity of the toolmaker.

Most of the milling fixtures are of the multi next type, some holding as many as twenty work pieces, each piece being held individually by a square head screw, and not by multi clamp device as would be expected. The time taken to load and unload the fixtures fitted in the manner described, appears to be very excessive.

Drilling jigs are of a simple design and are generally clamped to the table of the machine. One machine being set up as a composite drilling and tapping unit so that both operations could be carried out without the necessity to rejig.

Polishing and Finishing Department:

This department is particularly well laid out. A series of vertical racks held some hundreds of various types and shapes of grinding wheels. The majority of these wheels are of the cup type, they consist of a wooden bob about nine inches in diameter by 1 inch to 4 inches in depth with a rim of solid emery compound glued to the open edge of the bob. The rim varies in size from 1/4 inch to about 1½ inches wide by 3/4 inches in depth, the useful life of the emery surface is approximately 600 hours. To ensure freedom of cut an occasional light dressing of tallow type grease is found advisable, this also has a tendency to prevent clogging, especially when polishing nickel and brass. In addition to this treatment a compound similar to comman bath brick is occasionally applied to open up the surface of the emery compound and also to true up any irregularities that may have been caused by the work piece. These wheels are made on the premises and the secret of the emery compound is reported to be known only to one employee. The method of using these wheels for finishing exterior surfaces, is for the operator to hold the work by hand against the cutting edge of the wheel, the hollow of the wheel allowing him to vary the cutting angle of the work. Considerable experience and skill are required in order to obtain a good finish.

The method used for finishing the interior surface of drawing pens is to use a copper disc. approximately 10 inches in diameter by .050 inch thick. The disc is built up on one side only by the application of grit emery on to an oil base similar to that of linseed oil which forms a gummy base for the emery. The dressing is applied to the revolving disc by means of a piece of hack saw blade. After a few applications of the dressing a good emery base is formed, the disc needs re-dressing occasionally in a similar manner during use.

For polishing steel pieces with slots narrower than .060 inch an endless steel band is used. This is about .010 inch thick by ½ inch width with an exterior dressing of sodium silicate, powdered with various fine grits such as emery or fine carborundum. The steel band is run between two pulleys of about six inxhes diameter and 30 inch centres at a surface speed of approximately 1200 to 1500 feet per minute.

Manufacture of Planimeters:

The general machining operations are usually done in batches of 500 sets. Considerable use of Apprentice labour is made on the general machining, thereafter the parts receive their final

machining from highly skilled men. The fitting and assembling are done by individual craftsmen. The method of finishing the contact wheel differs considerably from that of other manufacturers, in so far that it is done entirely by a hand operation with the aid of a simple jig. The contact wheel, after having its pivot points suitably polished is mounted in a carriage and allowed to revolve freely without backlash or slackness on the pivots. This is in turn mounted on a base provided with a guider to allow a longitudinal movement parallel to the axis of the wheel spindle. The periphery of the contact wheel is lightly rubbed against a strip of fine emery paper about 1/4 inch wide, which is held tight by small clamps at the bottom of a steel trough of similar radius to the final shape of the contact wheel. A movement to and fro over the emery paper together with a slight rotation at each oscillation is made until the required finish and diameter is obtained.

Two men are employed to give the final inspection, checking and working out the constant of each individual instrument.

Output at time of Investigation.

Drawing Instruments = 400 sets per week a set comprising seven instruments.

Planimeters = 500 per month.

Protractors, Proportional Compasses etc. manufactured to order.

Price:

A set of good quality drawing instruments comprising seven instruments cost 34 marks retail.

The firm's prices have not risen more than the usual 10% to 15% over 1939 price.

Observations:

The speed and skill of the employees, especially in fitting and assembly adds greatly to the high quality and finish of the products. This coupled with the comparatively low wages and overheads enable the firm to market good quality instruments at extremely low prices.

SECTION 7.

Report On

| | |
|---|---|
| Firm: | Clemens Riefler |
| Location: | Nesselwang, near Füssen, U.S. Zone. |
| Person Interviewed: | Mr. Riefler. |
| Number of Employees: | Present Staff: 100<br>Pre-war Staff: 290 |
| Rates of Pay: | 76 Pfennigs to 90 Pfennigs per hour. |

Description of Firm and Products: This firm had, pre-war, an international reputation for manufacturing some of the finest drawing instruments in the world. At the time of our investigation, they were engaged in the manufacture of a limited range of instruments. The range consists of a set of drawing instruments (6 pieces) made in brass; proportional compasses, pantographs, beam compasses, and in addition the firm manufactures astronomical clocks.

The greater part of the firm's production is the manufacture of drawing instruments, which are of high quality and typical of skilled craftsmanship. The fitting, assembling and hand finishing are a noteworthy example of the labour available in this part of Germany.

The factory consists of a three floor building of approximately 30,000 square feet. It is modern, well lighted, and well equipped with comparatively new machinery. It is situated in a small village and provides the livelihood of most of the working inhabitants. According to Mr. Riefler, a considerable amount of his equipment and tooling have been removed, and this has resulted in a decrease in his range of products. There is no war damage to the factory.

Manufacture of Drawing Instruments: The type of instrument in production is the rounded limb type, which the firm has made famous. The limbs are produced from hot pressings in brass. Blanks for other parts are either cut from bar material, or blanked from sheet. All machining such as turning, milling and drilling are carried out on the premises, but a certain amount of the semi-finishing is done as out-work in the homes of the local inhabitants, the firm relying on this out-work to supplement output.

Instrument polishing and case making are carried out at a small works, about a half-mile distant from the main factory. The methods

used in the finishing and polishing are similar to those most widely used in Germany. The finishing of the compass limbs is done with emery cup wheels and they are finally polished on calico mops. Twelve skilled men are employed on the work, each having a number of years experience to his credit. They are mostly of middle age and extremely proud of their efforts.

The preparation of the case is done also at the branch, but the finishing is done as out-work. Women out-workers are employed to glue the plush material into the routed wooden top and bottom of the case, and fix the leatherette outer covering.

Manufacture of Drawing Pens: The method of manufacturing drawing pens is to cut the blanks to length on a circular saw fitted with a length stop, similar to that used for wood. The next operation is to turn the shank. This is followed by the slitting operation, each pen blank, being slotted individually. Other than drilling, all other finishing is carried out by hand work, the pen being rough shaped by filing. Hardening and tempering are done to the pens individually. It is interesting to note that the pen points only are treated, whilst the remainder is left soft.

Manufacture of Beam Compasses: The type of beam compass manufactured has a Vernier adjustment. The beam stick is graduated in millimetres with a Vernier reading to 1/10 m.m. In our opinion this Vernier adjustment is not considered accurate owing to the many points that were fitted, and the inefficient method of fixing them. No accurate means of checking the points is provided. Thus the effort put into dividing the beam and Vernier are wasted.

Present Output: 1,000 sets of Drawing Instruments per month, each set comprising the following:-

One compass half set and extension bar.
One pair dividers.
One spring bow divider.
One drop compass.
Two drawing pens.

The output of proportional compasses, pantographs, beam compasses, etc. appear to be comparatively small, and are possibly made to order only.

Price: A six piece set in case, containing:-

Half set and extension bar.

| | |
|---|---|
| Plain dividers<br>Spring bow divider<br>Two cross joint pens<br>Drop compass with ink and pencil points | 39.20 marks. |

Conclusions:

The quality of the products is still very high, though probably not quite so good as pre-war, Costs do not appear to have risen by more than the usual 10%. Here again, we see in this firm, a combination of high skill, low wages, and cheap overheads, which enables the German manufacturer to produce a good quality article at an extremely attractive price.

At present the firm is being restricted in its output of drawing instruments, owing to the difficulty of obtaining raw materials. If the material become available, we have every reason to believe that the firm is capable of producing on their pre-war basis once again.

SECTION 8

REPORT ON

| | |
|---|---|
| Firm: | Johann Lotter |
| Location: | Wilhemsdorf near Neustadt, U.S. Zone. |
| Persons Interviewed: | Mr. Johann Lotter |
| Number of Employees: | 72 men<br>23 women<br>18 apprentices |
| Rates of Pay: | 76 pfennigs to 90 pfennigs per hour. |
| Hours: | 48 per week of five days. |

Description of Firm & Products:

The firm manufactures a full range of medium quality drawing instruments. These are of very original design, both mechanically and in appearance. The factory is situated in a village about 20 miles distant from Nuremberg. All the labour is drawn from the village, and it is interesting to note that several generations of its population have been employed in the manufacture of drawing instruments. The trade was introduced to the village many years ago when it lost its basic industry of manufacturing silk stockings. Then the drawing instrument was introduced it was subsidised by the State. The factory is an old two storey building of approximately 6000 square feet. The machinery is very closely grouped, for instance, the main machine shop has 22 machines and 19 operatives packed into a space about 25 feet x 25 feet. The equipment consists of the usual light milling and drilling machinery, none of which is in very good condition. The workers appear to be very industrious and well disciplined and were skilled to a degree when the inspection of individual's work seems unnecessary. Some work such as the making of the pens, and fret cutting of the cases is done by out-workers in their own homes and taken back to the factory to be finished.

The products of this firm are of interest mainly for their originality in design, rather than for quality and finish. The types of instruments in production are as follows:- Compass half sets, dividers, spring bow compass, drop compass and drawing pens of various types.

Illustration Number II shows the general construction of the compass half-set with pen attachment.

(A) The method of centralising the knurled handle of the compass is unique. Pinion quadrants are cut on the compass legs, each moving about its own pivot points when pinions are in mesh.

(B) Locking nut for the telescopic extension bar which is carried in the leg of the compass.

(C) Knee action joint to limb.

(D) Fine adjustment.

(E) Pen with cross jointed nib.

Illustration Number III shows construction of geared head as incorporated in all compasses and dividers. Machining of this part of compass has to be done accurately, and assembly is a skilled operation. This type of head appears to give a smooth movement to the compass. It is claimed that compass can be used when opened up to 180 degrees.

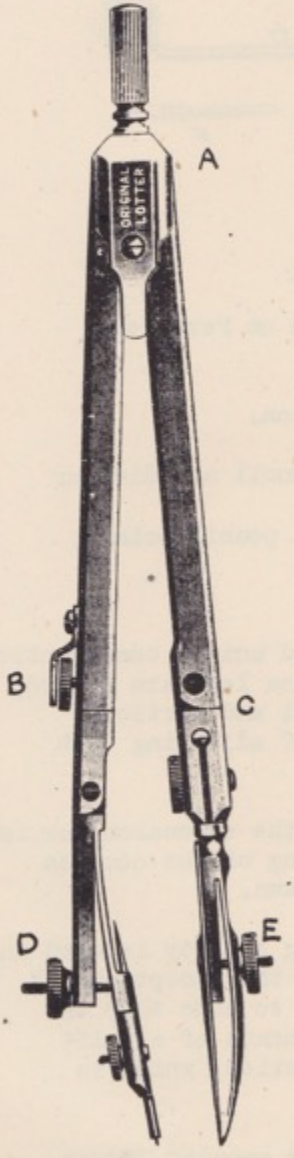



ILLUSTRATION NO II.

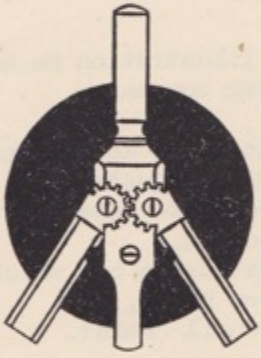


ILLUSTRATION NO. III.

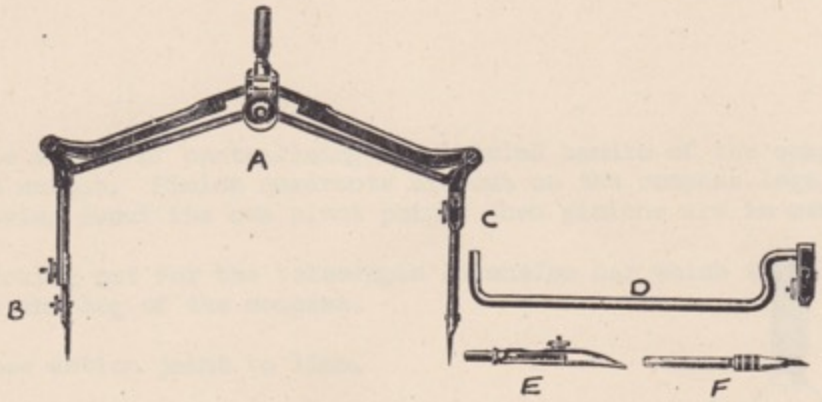



ILLUSTRATION NO. IV.

Illustration No.4 shows points of interest on Parallel opening compass:-

(A) Screw to lock compass in any desired position.
(B) Fine adjustment.
(C) Joint to accept extension bar, also pen, pencil and divider points.
(D) Extension bar which can accommodate pen and pencil points.
(E) Pen point.
(F) Pencil Point.

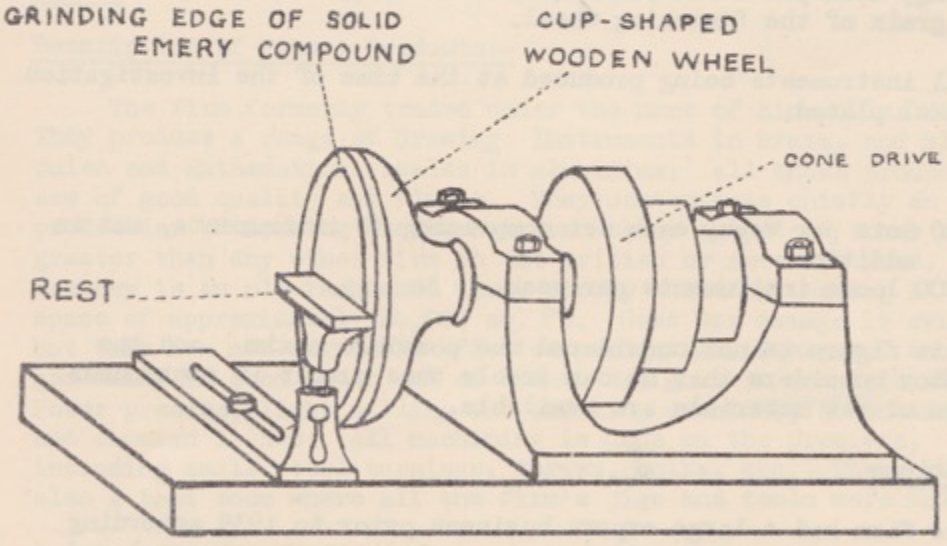
The Parallel compass is of an ingenious and unique construction which ensures that to whatever degree the compass legs are opened, the lower limbs move automatically in a parallel and vertical position to each other, without the necessity of adjusting each limb individually.

These advantages are maintained even when the extension bar is incorporated in the compass. The maximum opening of the compass will allow a circle of 20" in diameter to be drawn.

A special hard rolled brass of free cutting quality is used in the manufacture of compasses, with, of course, the exceptions of steel points and pen points. It is interesting to note that the fine adjustment of the compass limb is done by means of a split running longitudinally through the lower leg section, which is also made from brass.

The finishing and polishing are done by the popular German method, the finishing of the limbs being done as follows. The flat parts are ground on cup shaped wheels, the part to be ground

being held in the hand, and steaded against a rest set close to the surface of the wheel. See illustration No. V.




MACHINE FOR SURFACE-GRINDING OF COMPASS LIMBS

ILLUSTRATION NO. V.

These cup shaped wheels are composed of laminations of wood with a solid ring of emery forming the abrasive edge. This emery ring is cast in steel moulds from a mixture of emery and glue, three different grades of emery being employed and used in successive stages. A seasoning period of up to six months is required after casting, before emery ring is hard enough for use. This same type of wheel is used for hollows, etc., the contour of the abrasive edge being shaped to fit the parts to be ground.

For such parts as the inside surfaces of steel pens, spring bow compasses, etc., a steel disc coated with abrasive is used. Round or curved parts such as the outside surfaces of pens, are finished on leather covered wooden bobs, emery dressed, the periphery of the wheel being used in these operations. After finishing, most parts are polished on revolving calico mops to remove grain of the finishing wheel.

All instruments being produced at the time of the investigation are nickel plated.

Output

120 Sets per week, each set comprising 10 instruments, and in addition
1200 loose instruments per week.

This figure is not considered the possible maxim and the proprietor considers that he can treble this output if continuous supplies of raw materials are available.

Observations

The firm had a large export business prior to 1939 according to the proprietor, and supplied their products to Continental and American markets. At the present time, the policy on scales seems to be to deal direct with the Consumer and not through the wholesaler. The overheads of the firm must obviously be very low as the factory premises are situated in a rural district, the office staff being confined to the proprietor and one other clerk, and apparently there seemed to be no Foreman or Shop Managers demanding high salaries.

SECTION 9.

Report on

| | |
|---|---|
| Firm: | Bayerische Reisszeugfabrik A.G. |
| Location: | Nuremberg, U.S. Zone. |
| Person Interviewed: | Mr. Kassmann, Director. |
| Number of Employees: | Present Staff, 60, men, 60 women.<br>Pre-war staff of 250 |
| Rates of Pay: | Men: 1 Mk.10 Pf. to 1 Mk.50 pf. per hour.<br>Women: 60 pf. to 85 pf. per hour.<br>In some operations payment was by piece |
| Hours: | 40 to 48 per week of five days. |

Description of Firm & Products:-

The firm formerly traded under the name of Eichmuller & Co. They produce a range of Drawing Instruments in brass, and Slide rules and Mathematical scales in aluminium: all these products are of good quality and finish. They concentrate chiefly on the production of Drawing instruments and their output of these are greater than any other firm in the British or American Zone. The factory is an old-fashioned three-storey building, having a floor space of approximately 24,000 sq. ft. Some war damage is evident, but this has not seriously effected production. Equipment is generally in good order and of modern design. It consists of Power presses, light milling and drilling machines, automatic and capstan lathes; all machining is done on the premises, including small steel turnings, screws, bolts, etc. There is also a tool room where all the firm's jigs and tools were made.

Manufacturing Methods - Compasses.

The compass limbs are sheared on a heavy power press and then milled to shape. It is the practice of this firm to joint the shank on to the compass limb prior to milling. The inside edges are then milled with a duplex cutter: this has the effect of reducing the cutting load and improving the finish. The outer edge milling is performed by machining two limbs simultaneously, the fixture being arranged to clamp the pieces on either side of a fixed locating piece. The final milling operation on the limbs consists of rounding the head portion. For this the limbs are located together in pairs as in the final assembly, the hole in the head being used as location and centre of rotation.

A concave cutter is used mounted on the arbor of a light horizontal milling machine, the cutter is set at a correct radius and the limbs rotated by hand through 180°. Thereafter, until final assembly, the limbs are kept in pairs.

Polishing and finishing are done by the conventional emery cup wheels, calico mop, and felt bob which are dressed with crocus compound and rouge.

Pen Production

Method of machining pen points is as follows:- Oval section material is used. The shanks are turned to a finished diameter, or threaded as may be necessary, and finally parted off to length on Petterman pattern single spindle Automatics.

The milling of the slot is carried out by quite a novel method. The turned shank is gripped in a collet type adaptor, which in turn is held in a fixture attached to a vertical slide, which is free to return to its lowest point, by the lifting of a weighted lever. This lever is suitably loaded so as to apply the necessary feed to the slide when cutting, the work being fed to the underside of the saw. This method allows an automatic increase or decrease of feed according to the area of material being cut. The Works Manager considers it more economical to sharpen and replace the saws frequently, (as much as twice a day), with a production time of one pen per minute, than to decrease the feed of the work and spindle speed, to save saw sharpening and saw replacement time. The operator for these machines is a skilled man doing his own machine and work setting. Occasionally he is able to run three machines, but usually keeps two machines running, with the third as a stand-by.

Hardening and Tempering of Pens.

This is carried out on the premises with a gas heated furnace and salt bath tempering.

Finishing and Polishing of Pens.

These operations are carried out by skilled craftsmen. Extreme care is taken to ensure that point setting and profile is of a very high order. Each man views his work constantly through a high power magnifying lens. The exterior finish is also carried out by the individual craftsmen, and this gives to the completed pen a very superior finish. This firm makes also a super-quality pen from High Speed Steel, and we consider it to be the finest pen of its class manufactured in Germany.

This firm has a compact and convenient apparatus for grinding and polishing. This consists of a series of grinding and polishing wheels, mounted in the form of a tier with fine finishing at the top, intermediate grades of abrasive in between and rough finishing at the bottom. The speed at which this apparatus is run is approximately 1200 Revs per minute. This speed is the highest that we have encountered in Germany, for this type of work.

Aluminium Slide-Rule Production.

The rules are produced from two aluminium extrusions, one for the base and the other for the slide. Very little machining has to be done on these extrusions, except to tongue-groove the body to accept the slide. This grooving operation is done on a broaching machine. This machine has been designed and manufactured by the firm, its principle baing to draw by rack and pinion, the specially designed broach bars, which are built up in the manner shown in the sketch No. VI.

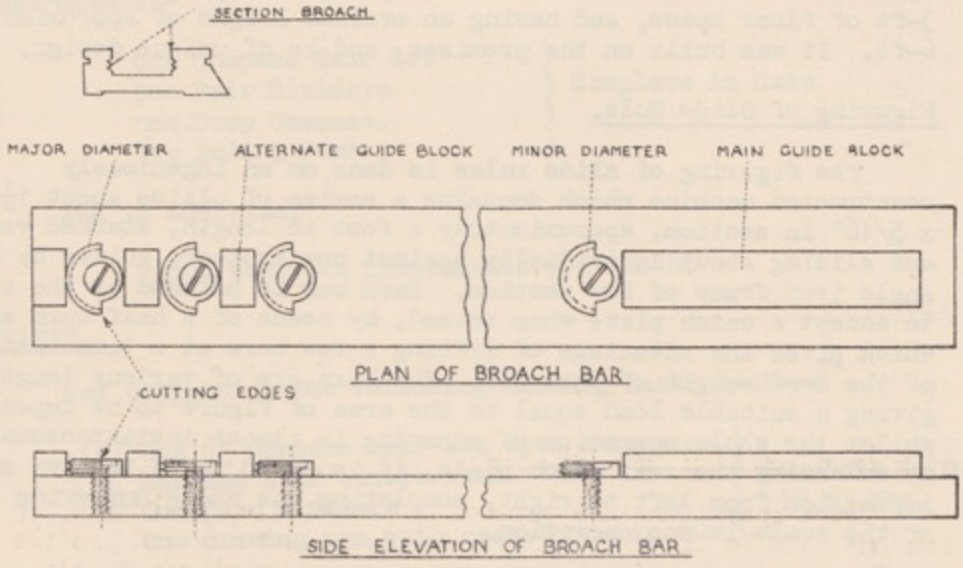



ILLUSTRATION NO. VI.

The front end of the bar carries a guide which registers with the extruded slide groove. The guide, in turn, is followed by a series of alternate circular form cutters, and guide blocks. The varying depth of cut is made possible by grinding back behind the centre line, which is the major width, and consequently gives gradual reduction in the size of cutters. When the last cutter on the bar needs grinding along with the others, they are all moved down one hole and the last one replaced by a new cutter of correct size, thus giving them considerable length of life. When the plain central Vee groove is brought out to size, the process is repeated, in the same way, by passing through a broach bar with grooving cutters.

The total length of broach possible on this machine is approximately 30".

Dividing of Slide Rule.

This is done on a straight line dividing machine, which is set by hand-operation, the operator taking a microscopic reading from the master plate. Ten slide rules are divided simultaneously at each operation. This machine is most compact, taking only 3-ft. by 3-ft of floor space, and having an overall height of approximately 6-ft. It was built on the premises, and is of unique design.

Figuring of Slide Rule.

The figuring of slide rules is done on an ingeniously constructed machine which contains a series of plates about $1\frac{1}{2}$" x 5/16" in section, approximately a foot in length, stacked vertically and sliding about individually against one another, guided by an angle iron frame of box section. Each bar is notched at the rear to accept a catch plate when raised, by means of a half turn scroll, which gives the advantage of lifting a few bars at a time instead of the dead weight of them all. The bars are of various lengths, giving a suitable load equal to the area of figure to be impressed, whilst the whole operation of stamping is almost instantaneous. By releasing the rear catch plate, it is so adjusted to give succesive impression from left to right, completing the whole numbering of the scale in one operation.

The figure stamps are square in section, ground on the sides, and fitting neatly into a guide plate in their respective positions. Whilst this method of marking is admirable for metal rules, it would be quite useless for rules made from plastic, or wood.

This machine was also designed and constructed by the firm

Finishing

After dividing and figuring the rules are anodised and filled in with colours in the usual manner.

Production of Mathematical Scales (Triangular Section)

These scales are produced from extruded aluminium. The only machining necessary on the extrusion, is to true the surface of each face of the rule on a milling machine. The dividing is done on an automatic straight line dividing machine, one face on each of three rules, being divided simultaneously. After dividing, the rules are anodised by the sulphuric acid process. The filling is the final operation, and is done in the orthodox manner.

Output

The following figures are quoted by the firm but are considered to be very conservative.

18,000 sets per month, each set containing the following instruments:-

| | |
|---|---|
| One Compass Half Set<br>One Pair Dividers<br>One Drop Compass.<br>Two Ruling Pens | Complete in Case |

and in addition,

2,000 separate instruments per month.

Prices

Set comprising the following drawing instruments:-

| | |
|---|---|
| (a) One 6" compass half set with extension bar and self centre head<br>One pair dividers<br>One drawing pen with cross opening nib | Complete in Case: 12.85 Mks. |
| (b) Set similar to above, but including:<br>One drop. compass with pen and pencil points, and<br>One extra drawing pen | Complete in Case: 18.75 Mks. |
| (c) Slide rule - 10" standard pattern in aluminium | 14 Mks. |

Observations

This firm has planned tooling and machining very efficiently, and is capable of a very high production rate per man hour. Wages paid by this firm are the highest encountered in the German drawing instrument industry.

The cost of the finished article has not risen more than 15% since 1939.

SECTION 10

REPORT ON

| | |
|---|---|
| Firm: | Mayr & Hormann |
| Location: | Pfronten-Steinach, near Kempten, U.S. Zone |
| Persons interviewed: | Mr. Freka, Works Manager<br>Mr. Gottleib Schneider, Works Engineer |
| No: of Employees: | 180 of whom 50 are employed on Drawing Instruments |
| Rates of Pay: | 76 Pfs to 90 Pfs per hour - men<br>50 Pfs to 76 Pfs per hour - women |
| Hours: | 40-48 hour per week of 5 days |

Description of Firm & Products:

This firm manufactures a full range of Drawing Instruments, of good quality, Planimeters of the simple fixed scale, and graduated sliding bar types, Pantographs and Proportional Compasses. In addition to these products, the firm is also manufacturing jigs and tools on a commercial basis. The manufacture of these jigs and tools accounted for approximately 70% of firm labour force at the time of our investigation, but it is the policy of the firm to increase considerably the proportion of labour employed on Drawing Instruments.

The factory is a modern three-floor building, having a total floor-space of approximately 40,000 sq. ft. It is situated in a small village in rural surroundings, a few miles away from the village of Pfrontein Reid, where Gebruder Haff, who also manufacture drawing instruments, have their factory. Thus it is possible that there is some interchange of skilled labour.

Pre-war, the firm also manufactured a limited range of slide rules of the orthodox construction, i.e. Wooden base and slide with celluloid facings.

Like many other drawings instrument manufacturers in Germany, Messrs. Mayr & Hormann had a large export trade for their Drawing instruments, Planimeters, etc.

Equipment:

This consists of a range of machine tools including 60 m.m. capstans, surface and cylindrical grinders, jig borers, light and heavy milling and drilling machinery, hydraulic and power presses.

Although all this machinery is not directly employed on the production of Drawing Instruments, it is available to make jigs and tools for production of those instruments.

Manufacturing Details, Compasses.

Most of the Drawing Instruments are produced in nickel alloy, but some quantity of instruments are produced in brass nickel plated. In order to save metal the compass legs made from flat section material are split with a slitting saw as per Sketch No: VII. below:-

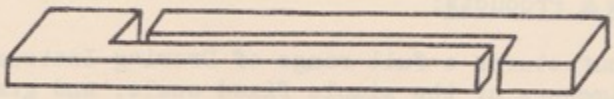


ILLUSTRATION NO: VII.

After splitting, the parts are milled to finished section, usually on milling machines adapted with fixtures according to the operation.

All compasses have link operated compensation to centralise the knurled handle, an effective method similar to the better class of instrument produced in England.

All steel parts are finished by the popular German method i.e. emery and glue compound rings super-imposed on the wooden bobs. One great advantage in the use of this type of wheel is that it is unnecessary to remove the scale or carbon deposit before applying the workpiece as the deposit has no detrimental effect on the face of the wheel or on the high finish it is possible to attain on the workpiece. Another important point is the coolness of the cutting by this method.

For the polishing of the Nickel and brass, simple methods such as emery discs and bands are used. The final polishing is done on cloth mops dressed with the usual compounds. One interesting point noticed in the polishing department, is that all polishing spindles are raised only about 18 inches above the floor level, the operator either sitting or kneeling on a cushion placed on the floor.

Planimeters:

These instruments are similar in almost every respect to these produced by A. Ott of Kempten.

For the simple fixed beam and graduated beam polar types of Planimeter, all castings used are zinc die castings. The graduated beams are produced from square section tube in a nickel alloy material.

In the manufacture of the instruments considerable attention is given to the contact wheel periphery. This is finished by means of a simple crank which is operated by a connecting rod. This in turn is coupled to a cross head block running between parallel slide bars. In this manner a straight line motion is given to the fixture mounting which holds contact wheel spindle. Automatic rotation of the wheel is provided for, the complete cycle of rotation of the contact wheel being approximately 10 minutes. The abrasive used is a block of fine Arkansas stone which is fixed to the base of the machine. It remains stationary and is immediately below the spindle mounting fixture.

Proportional Compasses:

A limited quantity of these instruments are in production, and we are informed that the firm can manufacture seven different types, these range from fixed ratio quarter dividing and bisecting type to adjustable ratio type reading from 1½ to 10. An interesting feature of one of the Proportional compasses is the fine adjustment provided by fitting rack and pinion.

Output:

Drawing Instruments 300 sets (22 pieces) per month.

Planimeters, approx, 200 per month.

These figures are applicable only to the period of investigation and may be substantially increased by the time this report is published.

Observations:

The firm is in the process of turning over from war to peace time production. No doubt when this change over is completed the major part of their output will be Drawing Instruments and the manufacture of jigs and tools will have declined. The firm has a nucleous of highly skilled craftsmen who are skilled in the manufacture of Drawing Instruments. Providing materials and labour

are available they are capable of a tremendous output of first quality instruments. If present wage standards are maintained along with the low overheads this firm could produce at a very much lower price than is possible in Britain.

SECTION 11.

REPORT ON

Firm: Lotter & Company.

Location: Neustadt.a. U.S. Zone.

Person Interviewed: Madam Lotter (wife of proprietor)

Number of Employees: 14 Men.
2 Women.
1 Outworker.

Rates of Pay: 76 to 90 Pfennigs per hour.

Hours: 48 per week; five day week.

Description of Firm and Products.

The firm is manufacturing a very limited range of medium quality drawing instruments. The design of these instruments is very similar to that of the nearby firm of Johann Lotter, and it is obvious judging by the similarity of manufacturing methods, that the two firms are closely connected, the outstanding feature common to both being the geared head of the compass.

The factory is a two storey building of approximately 1000 square feet. The business has been moved to these premises, following the destruction of a previous factory by bombing. The equipment consists of the usual light milling and drilling machines none of which are in particularly good condition.

The range of instruments being produced is limited to one type of set containing the following:-

Compass half set.
Dividers
Spring-bow compasses of the C spring type
Drop compass
Ruling pens.

These are all made from brass, nickel-plated. All the small steel turnings were obtained from Switzerland until the end of the war.

There are no outstanding methods either in tooling or machining. The compass and divider limbs are cut to length from rectangular section brass rod and are milled to shape. The pinion quadrants are cut on the compass legs by a machine specially rigged up by the firm.

Ruling pens are not made on the premises, but are made by outworkers in their own homes.

The finishing and polishing of the instruments is done by the usual German method with emery cup wheels, and mechanically operated calico mops.

Observations.

Here again we find a typically small family concern producing their instruments in workshops attached to residental property under factory conditions, which are far from good. Craftsmanship and design, however, are quite good, and there is no doubt that with the low overheads and cheap labour, the firm can sell its products at a very competitive price. Prices have not risen more than the usual 10% to 15% since 1939.

SECTION 12.

REPORT ON

FIRM: Hermann Kraft

LOCATION: Neustadt.a. U. S. Zone

PERSON INTERVIEWED: Mr. Hermann Kraft

NUMBER OF EMPLOYEES: 11 Men
14 Women

RATE OF PAY: Men: 80 pfennigs per hour (maximum)
Women: 50 pfennigs per hour

DESCRIPTION OF FIRM AND PRODUCTS: The workshops consist of two floors of the proprietor's dwelling. This business is run very much as a family concern, and is a typical example of the small type of firm which seems to flourish in Germany on the manufacture of instruments. The premises are situated in the lower class district of the town and overheads would appear to be extremely low. The working conditions are very bad indeed, machinery being unguarded and dangerous to the employees, very little space being permitted for the operatives, such conditions would certainly not be permitted in England. The type of instruments manufactured is of the lowets school quality, most of them being made in zinc and a small proportion in brass. The following instruments were in production at the time of our visit:-

Compass Half Set with Extension Bar
Dividers
Spring Bow Compass Combination Pen and Pencil
Ruling Pen

The output of these instruments is tremendous in comparison with the number of people employed. The price charges for these articles is extremely low and we doubt if anything could be produced in the English market at such low cost. The Proprietor informed us that prior to 1939, he had steady export trade for his goods in India and China.

The compass limbs are produced from extruded section zinc rod, which is cut to length and milled to shape, the knurled finger grip being a zinc die-casting. All needle points, screws, nuts, etc., were bought until 1945 in bulk quantities from Switzerland (screws at 2.25 Swiss francs per 1000) and the firm have stocks still in their possession.

The assembly work on the instruments is done largely by

women, and obviously with such low quality instruments, very little fitting is done.

The ruling pens are made from steel, which seems rather unusual in such cheap quality instruments. They are cut to length from oval section material and shaped and slotted on milling machines. The minimum of finishing is carried out on them, and in our opinion they would be practically useless as instruments.

Output

The firm claimed to produce 4000 instruments per week at the time of our investigation.

Price

A set complete in case lined with cheap velvet comprising half set with extension bar, divider, spring bow compass combinations pen and pencil. Spare points case. This sold at seven Marks, retail.

Observations.

The selling price of these goods must leave a very small margin of profit. The proprietor certainly does not appear to be prosperous and lives in a very unpretentious manner. Nevertheless, he seems to take a very keen interest in his business. The quality of the firm's products is extremely low, but the instruments are designed to catch a market which deals in a cheap imitation of the better quality instruments.

SECTION 13.

REPORT ON

| | |
|---|---|
| Firm: | Christof Birk. |
| Location: | Neustadt.a. U.S. Zone. |
| Persons Interviewed: | Mr. Christof Birk and his son. |
| Number of Employees: | 13 Men.<br>2 Women. |
| Rates of Pay: | Men: 76 Pfennigs to 80 Pfennigs per hour.<br>Women: 42 Pfennigs to 50 Pfennigs per hour. |
| Hours: | 48 hours per week of five days. |

Description of Firm and Products:

The factory is a small building adjoining the proprietor's dwelling. It consists of a modern building well lighted, on two floors having an approximate total area of 2,000 sq. ft. of floor space, and it was obviously constructed to meet the requirements of the proprietor's trade. The factory is adequately equipped with the necessary machinery to manufacture drawing instruments, and at the time of our visit was working at about 50% of its pre-war output, this being due to the lack of staff, raw materials, etc. Prior to 1939 the firm produced a very extensive range of high quality drawing instruments including the old English pattern and also patterns popular in the American markets. Comparing samples of pre-war with those of present production it would appear that the quality of the instruments has not deteriorated. At the time of our visit they were engaged upon a limited range of good quality instruments made to the Richter pattern and comprise the following range:-

Compass half-set,
Dividers,
Spring bow compasses,
Drop Compasses,
Ruling Pens.

We were informed that, pre-war, the firm had a good export trade to the United States and also to Britain. It is our impression that the overheads to this Establishment must necessarily be very low. The proprietor and his son are both craftsmen and engaged upon production. The clerical staff consists of only one person.

Equipment of Factory.

This consists of the usual small hand milling machines, turret lathes, engine lathe, power press and a battery of grinding and polishing heads.

The manufacture of the instruments follows the usual practice. Tooling is good, but it is the high skill and speed of the craftsman which plays such an important part in the high quality and finish. Fitting is chiefly done by men and the production is very high, very little supervision or inspection being necessary.

Finishing and polishing are done by the usual German method with emery cup wheels and calico mop, and here again, it is noticeable that the operative is skilled and carries through the work in a conscientious and thorough manner.

Price.

The following are examples of typical sets as supplied:-

(a) Set of nine instruments in lined case - 38 marks.

(b) Set of six instruments in lined case - 25 marks.

These prices subject to 30% discount to wholesalers.

These prices have not increased by more than 10% over the 1939 price.

Observations.

The price of these high quality instruments is ridiculously low at the present rate of exchange to the equivalent English instruments, and puts competition by this country out of the question. It is our impression that the firm are working on a very small margin of profit and that the proprietor is taking very little out of the business.

SECTION 14.

REPORT ON

| | |
|---|---|
| Firm: | Rudolf Nestler |
| Location: | Lahr, Baden (French Zone) |
| Person interviewed: | Mr. Rudolf Nestler |
| Number of employees at time of visit: | 25 men, 15 women. |
| Number of employees pre-war: | 60/70 people |
| Present rates of pay: | 76 pfg. to 90 pfg. per hour. |
| Hours: | 48 per week of five days. |

Description of Firm and Products.

The firm is owned by Mr. Rudolf Nestler who is a brother to Albert Nestler, the Slide Rule manufacturer. The two firms are run as entirely separate businesses.

The firm of Rudolf Nestler is concerned entirely with the manufacture of good quality drawing instruments. The factory is situated in the centre of the town, only a short distance away from the factory of Albert Nestler. It is a three-storey building, well lighted and equipped with machinery for the manufacture of drawing instruments and components such as screws, needle points and case making. The total floor space is approximately 10,000 sq. ft. The premises have suffered very little damage from the effects of bombing and gunfire, and no equipment had been removed by occupying forces.

The business appears to be well organised and efficiently run with good working conditions for the employees. The instruments in process of manufacture at the time of our visit consisted of a limited range, this being due to the usual shortage of raw materials, labour and fuel. The following is a list of the instruments in production:-

Compass half-set with extension bar
Dividers
Compass spring bows, pen and pencil points
Drop compass
Ruling pens and dotting pens
Beam Compass (Graduated wooden beam)

These instruments are of good quality and finish. The general design and construction being very similar to some of the English machine made instruments.

Details of Manufacture

The compass limbs are produced from brass stampings. These stampings being bought from a firm who specialise in this type of work. Prior to machining the stampings are flattened on a press at the Nestler factory. The machining is carried out on standard types of light milling and drilling machines, operations being principally hand and not power fed. The general standard of machine finish is not high and they depend on polishing to produce the final good appearance.

The fixtures used are of simple design, work pieces being held by screw clamps. A favourite milling method is to mount work on one end of a simple lever and raise it against the cutter.

The pens are slotted on a milling machine. For this operation they are mounted six at a time into a jig which is built to give rigid support to almost the entire length of the workpiece. They are fed automatically past the cutting head.

It is the practice of the firm to work in batches of 5000 pieces at a time, as this quantity has proved to be an economical batch to work with the present staff.

Finishing and Polishing.

This is done by the usual German methods. The flat parts are ground on cup shaped wheels, the part being held in the hand and steadied on a rest set close to the surface of the wheel. These wheels are wooden with a solid ring of emery forming the abrasive portion, different grades of emery being used in successive stages. For inside edges a disc coated with abrasive is used, the work piece being held by hand. The final polishing is done on revolving calico mops. Much of the quality of the finish by this process depends upon the skill of the operator.

Plating.

A plating shop formed part of the equipment of the firm. The degreasing is done by the usual Trichlorethylene process. Nickel plating is done in the conventional vats. Parts to be plated are assembled on frame type jigs, the practice of wiring together only being used for small quantities. Owing to the scarcity of nickel anodes plating is not always possible.

## Case Making

This is carried out in its entirety on the premises and is worthy of special note, as this firm's methods differ from most other German manufacturers visited. The majority of firms favoured a method of fret cutting and mounting on to the base to achieve the recessing in the case, but this firm practise a method of routing the recess into the prepared base of the case. This is done in the following manner: the base and lid of the case are first shaped and then fitted individually into a jig and routed to the required contour by moving the jig against a locating pin on a template which is mounted on the underside of the jig. The routing head is mounted vertically, and in a fixed position. This method seemed to be very accurate and efficient and would appear to be cheap, it could well be recommended to English manufacturers.

## Prices

Set of Drawing Instruments in case, comprising the following:-

| | |
|---|---|
| Compass Half Set and extension bar<br>Dividers<br>Drop Compass<br>Drawing Pens (2) | 30 marks retail. |

These do not appear to have risen by more than 15% over 1939 prices.

## Observations

This firm is producing good quality Drawing Instruments, of conventional design, very similar to instruments produced in Britain. There is nothing outstanding in their production methods, which would account for a great saving in cost over the British article. Therefore, apart from any slight difference in general overheads, it is obvious that the firm can produce at a lower price mainly on the difference in cost of labour.

SECTION 15

REPORT ON

FIRM: J. Rumold

LOCATION: Zuffenhausen, Stuttgart, U.S. Zone

PERSON INTERVIEWED: Mr. J. Rumold.

NUMBER OF EMPLOYEES: 8 men, 12 women

NUMBER OF EMPLOYEES (PRE-WAR): 45 to 50

RATES OF PAY: 50 pf. to 90 pf. per hour.

HOURS: 45 per week of five days.

DESCRIPTION OF FIRM & PRODUCTS:

The firm manufactures a range of the following instruments:-

Mathematical Scales, faced in white celluloid, machine divided.
First quality.

Mathematical Scales, plain wooden, machine divided, Technical School quality.

Rulers, faced in white celluloid, machine divided.

Rulers, wooden, embossed.

Straight Edges, wooden.

Gauge rulers, metre and a double metre in wood, unjointed.

All these products were in manufacture during the period of our investigation. The factory has a total floor space of 7,000 square feet and consists of a three storey building and a separate single storey building used as a spraying shop. The whole is well laid out and is equipped with modern machinery, it has suffered no war damage, except for the timber drying and storage sheds of approximately 2,500 square feet which had been completely destroyed by bombing. The factory is compact and efficiently run, and is producing good qualities of medium quality instruments. Pre-war, the firm sold a large percentage of their output to America, their agents in that country being Messrs. A. Lietz & Co. of San Francisco.

DESCRIPTION OF EQUIPMENT: The machinery is of the usual light good working types, and is in good condition. It consists of circular saw benches, spindle-moulders, belt and drum sanders, band-saws, etc. Dust-extraction plant was fitted throughout.

The dividing machinery is manufactured by Amsler of Switzerland, and consists of four straight-line dividing machines, each machine having eight cutting heads, and having capacity to divide eight rules, twelve inches in length, simultaneously. The figuring is done on a series of small hand-operated hot presses. A small platern printing press is installed for the embossing of cheap rules.

Pressure spraying plant and mechanical polishing apparatus are installed for finishing and polishing.

DETAILS OF MANUFACTURE.

Triangular Section Scales.

The general method of production is quite orthodox. The Shaping of the triangular scale being done on a spindle moulding machine. The faces of the rule are finally toothed on this machine in order to present a rough surface and so effecting good bonding with the celluloid face. When applying the celluloid faces to the wood, the strips of celluloid were first moistened on one side only with a solvent solution. They are then laid down immediately on to the wood with vigorous hand rubbing. Three celluloid faces only are laid at the first stage and then the rule is put aside for a week in order to allow it to dry. Afterwards, the opposite three edges are laid in a similar manner, and the whole allowed to dry for a further week. The faces are then scraped down by hand to the final contour and are then ready for dividing.

The dividing of the scales is carried out on a straight line automatic dividing machine, eight scales being divided simultaneously.

The figuring is done on small hand-operated hot presses. Filling and rubbing down are done by hand.

The final polishing is done by first spraying the rules with a cellulose varnish, and afterwards polishing on a mechanically operated polishing mop.

OUTPUT: Twelve inch celluloid-edged triangular scales at 500 per month. Other products according to demand. In 1944, the firm had a total turnover of 221,900 R.M. At this time they were employing thirty people.

COSTS: Twelve-inch celluloid-edged mathematical scale is 4 M. 50 Pf. retail.

Twelve-inch plain wooden triangular mathematical scale is priced at 1 Mark retail.

These prices are 10% advance on 1939.

OBSERVATIONS: This firm like many others in the German Drawing Instrument Industry, relied on export to the American and other overseas markets to absorb a large proportion of their output.

SECTION 16

REPORT ON

FIRM: A. OTT.

LOCATION: KEMPTEN ALLGAU. U.S. Zone.

PERSON INTERVIEWED: Mr. Hermann Ott.

NUMBER OF EMPLOYEES: 150 men.

RATES OF PAY: 1 mark per hour.

Description of Firm & Products.

This firm specialises in the manufacture of high grade scientific instruments such as Planimeters of various types, Pantographs, Radial and Square Root types of Integrators, Seismagraphs and Current meters. Their main interest lies in designing and producing highly specialised instruments, and not in mass production of standard types. The factory is a very modern building of three stories, having a total floor space of 30,000 square feet. The equipment consists of high class precision light to medium machines, none of which are more than three years old. There is also an outstandingly good tool room which not only supplies all the firm's own requirements but also caters for commercial toolmaking. The drawing office employs a staff of seven designers and draughtsmen.

Planimeters.

The most interesting point in the manufacture of these instruments is the considerable care which is taken in the final finishing of the contact wheel. The outer periphery of this wheel has to be finished so that it has a fine tooth which will grip the surface on which the planimeter is working, and so ensure that the contact wheel does not skid, giving an inaccurate measurement. In order to achieve this finish, fine microscopical lines are produced on the wheel periphery parallel to the axis of the spindle. The machine used to give this finish is very compact taking a bench area of approximately 18 inches by 12 inches. The contact wheel with the spindle assembled is mounted by its conical pivots onto a carriage having a reciprocating motion with about 3 inches of traverse which is operated by an electric motor driving a simple crank. Incorporated in the mechanism is a ratchet rotating device giving the contact wheel a minute rotation at each reversal of the crank. The abrasive

used is a fine Arkansas stone.

Apparatus for Solving Differential Equations.

This apparatus is well worthy of mention. It has been developed in conjunction with the authorities of Darmstadt Technical School. Development work has taken place since 1941, and several of these machines have been built. The one at present under construction is made under unit construction principles, and consists of six such units. These can be connected together electrically from a main switchboard, and results are passed from one unit to the next, by synchronous motors. The integrating apparatus is mainly mechanical, and torque amplifiers are employed to enable slight movements of the integrating wheel to move fairly heavy tables. A photo-electric follower is incorporated to enable a differential current to be fed into the machines, and this seems to operate extremely well. It is arranged on the split beam principle, the image of the photo-cell being half dark and half light and must automatically follow the curve. It is stated that the accuracy of following is better than .2 mm. in most cases, although it is dependent on the shape of the curve.

Harmonic Analyser

This apparatus is also in production, and its function is to evaluate the 1st, 2nd, 3rd and 4th harmonics of an oscillatory curve.

Here, as in the case of the apparatus for solving differential equations, the theory is so complex, that we consider it to be the work of an expert mathematician to describe completely the theoretical basis alone.

Tide and Current Meters.

A vert extensive range is being manufactured from hand instruments to large standard equipments for Hydro-electric plants. Elaborate test tunnels have been constructed underneath the grounds surrounding the works. These are used to test by artificial means, most of the types of flow meters, which are being manufactured.

Observations

From the foregoing description of some of the firm's products it is obvious that the firm is capable of designing and

constructing the most intricate and involved scientific and mathematical instruments. This is due, no doubt, to the inspiration, which comes from the management, the members of which have a full appreciation of the mathematical principles involved, and who are capable of directing their staff of experts to develop these highly specialised instruments. The whole atmosphere of the firm denotes efficiency, right down to the point of training the apprentices. The party feels that much additional technical information could be derived by further investigation by expert mathematicians.

SECTION 17

REPORT ON

FIRM: Geo. Kessel

LOCATION: Kempten, Allgau, U.S. Zone.

No. of EMPLOYEES: 30

PRODUCTS: Dividing and Engraving Machines.

Description of Firm & Products.

This firm specialises in the manufacture of dividing and engraving machinery and its machines are to be found installed in many of the German Drawing Instrument firms. The factory is of the single floor type, having an approximate total area of 6,000 square feet, and it is equipped for general light engineering. The premises have received only superficial war damage and this has not effected production. At the time of our investigation, work was in full swing.

The firm manufactures various types of dividing machinery but the following description is limited to those machines of interest to the Drawing Instrument trade. They are Straight line dividing and circular dividing machines. These machines possess many points of outstanding interest, among them being an angular adjustment of the dividing head permitting dividing of diagonal scales, bevelled edged ruler, etc. Although fully automatic there are attachments for hand operation only, i.e. for circular dividing on the straight line machine, and for straight line dividing on the circular machine.

THE CIRCULAR AUTOMATIC DIVIDING MACHINE: which has a radius of 25", can be adjusted to cut straight and curved divisions. It can be run at eight different speeds and will operate either clockwise or anti-clockwise. It is so designed that it can be reversed to cut in perfect register without the necessity of resetting. By the use of a special attachment the machine can be adapted for straight line dividing, but by hand operation only. The cost of the machine, including accessories, is 7500 R' marks.

THE FULLY AUTOMATIC STRAIGHT LINE DIVIDING MACHINE, operates on two metal scales, or four boxwood scales, simultaneously, up to a length of 1200 cms. It will operate in both directions and its speed is approximately 100 divisions per minute. The machine has an attachment which will permit circular dividing. Cost of this machine with all accessories, including grinder, is 11,000 R'marks.

OBSERVATIONS:

The firm is producing fine precision machinery. Their prices are extremely low, and at present rates of exchange it would be impossible to produce such machines at equivalent prices in Britain.

SECTION 18

## CONCLUSIONS

### Prevailing Conditions:

The German Drawing Instrument Industry is still exceedingly virile, and as can be seen from the foregoing reports, the majority of the firms are producing on a modified scale. Generally speaking, the industry is still capable of resuming its output on an almost pre-war level, if allowed to do so.

Factory premises and equipment have suffered very little from the effects of war damage.

### Re-organisation of Industry:

The industry is now engaged in re-organising on a pre-war basis. This is, of course a slow process under the circumstances, which prevail in Germany today. Progress is held up mainly through scarcity of raw materials, of fuel and labour.

### Output:

This was built up in pre-war days, to cover not only Germany's domestic requirements, but to allow also a vast international export trade. We would consider that the present output of drawing instruments and slide-rules is very considerably below pre-war level, but even so, in our opinion production in Germany today far exceeds that of any other European country.

### Quality of Instruments:

Whilst the industry produces a complete range from the lowest to highest quality goods, the output of the higher quality instruments is far in excess of the lower quality. At the present time, the quality has deteriorated slightly through lack of suitable material. The skill and industry of the workmen play a considerable part in producing a high level of craftsmanship. They are aided in most instances by having good equipment and tools.

### Manufacturing Process:

The points which impressed the party most were as follows:-

### Manufacture of Slide Rules:

1. Elaborate equipment and layout as seen in the firms of A.W. Faber-Castell, and Albert Nestler.

2. The method of graduating by a hot press process used by A.W. Faber-Castell and Dennert & Pape.

3. Unique dividing machinery, and also the many special purpose machines devised by Albert Nestler to eliminate hand operations.

Manufacture of Drawing Instruments.

The following points were of special interest.

1. The vast scale on which instruments are still produced. Jigs and tools were generally speaking quite elaborate.
The machines used were of orthodox type, and in the majority of cases, were of modern construction.

2. Finishing and Polishing.
The German industry as a whole favours a uniform method. This is of special interest to the British manufacturer, as it was considered that the pre-war finish on higher quality instruments produced by Germany, was outstandingly good. The process is described in the foregoing reports.

Production Costs.

The costs of production are comparatively low, especially compared with those of this country, the reasons for this being,

1. The vast scale of production must of necessity reduce the cost of the individual article.
2. Wages of the workmen are also comparatively low, the average wage for men being 1 mark per hour, and women, about 60pfennigs per hour. These wages are consistant with the standard of living in Germany.
3. The overheads of the majority of the factories are also unusually low. The factories are situated mainly in villages, where land and building costs are cheaper, and where the local labour is dependent upon the factory for its livelihood.

Working Conditions.

The hours worked in the industry at present are to some extent dependent upon the supply of raw materials, fuel and power etc. Generally speaking, the number of hours worked is 40 to 48 hours per week, the working week being spread over five days.

Final Conclusion.

There is a large capacity for the manufacture of all types of drawing instruments and slide rules in Germany today.

These instruments can be produced in quantities far in excess of Germany's requirements, and at low prices, with which we, in this country, could not possibly compete.

## DRAWING INSTRUMENTS
(Resume of German Practice)

Mayr & Hormann.
Gebr. Haff.
C. Rieffler.
Bayerische Reisszeugfabrik.
Nestler.

DRAWING INSTRUMENTS Material (non-ferrous)

The general material position is bad, nickel silver is not readily obtainable and brass is being used for a number of instruments. All makers, although normally making an extensive range of instruments are now engaged on a simple "utility" type of half set, similar to our own so far as components are concerned, but differing of course in style and material. Limbs are made in various ways; in two cases stampings are used made from brass strip, or the limbs are machined from the solid strip. Brass hot pressings are used for the pencil points in one case. Some of the firms are using zinc strip, but they are unanimous in their condemnation of this material, and it is only being used as a substitute under protest.

DRAWING INSTRUMENTS Machining.

Most of the machining follows orthodox lines, small milling machines are used extensively, and there were few multiple fixtures. Shaped vice jaws are used almost exclusively and cutters are Standard form. Occasionally we saw one operator tending two machines, but as the vast majority of operations are very short, it is obviously not economical in the majority of cases.

Practically all drilling was done one hole at a time in jigs which were clamped to the drilling machine table, the general method of operation was as follows - the component was pushed into the jig, held there with the left hand, drilled and withdrawn practically in one movement, an air blast came into operation by foot pedal, and blew the swarf out of the jig, and the next component inserted. This method is certainly very fast, and a rate of 200 holes per hour is easily maintained. Locations in the jig itself were not too precise as one of the fundamental factors was that the components must go into, and be withdrawn from the jig easily. Drilling speeds were generally fairly high but not excessively so and approximated very closely to our latest practice.

Tapping operations were carried out on a simple tapping machine similar in principle to the small double cone machines which we have in use, but arranged to work horizontally. Generally speaking operators were not allowed in the better class firms to sharpen drills and taps etc, or to interfere with the setting of the machine, and work seemed to be proceeding without much trouble.

DRAWING INSTRUMENTS (Pens).

Pens were made almost exclusively from section steel, cast steel, silver steel and high speed steel, being used according to their availability. None of the firms we visited were using stainless steel as it is not at present available, but all the firms who had used it were not very enthusiastic about it, as they said it could not be hardened at the tip to anything like the same extent as cast or high speed steel, and this was considered to be one of the essentials of a good pen.

MACHINING (Pens).

The general machining of pens followed the usual practice, they were first shanked at the end or screwed on a Capstan lathe according to the type, in one or two cases the ends were rough taper turned to form the nibs, then they were slotted; this slotting operation although differing in detail in the various firms was fundamentally similar in all of them. A circular slitting saw, approximately 6" diameter, 10 teeth per inch, is revolved in a milling machine of orthodox design at about 120-200 R.P.M. the pen is pushed into a simple jig and locked by a lever and fed past the saw, in one case two saws were mounted side by side and two pens were slotted at one pass. The whole arrangement is liberally flooded with a soluble oil emulsion and this slotting operation is done at the rate of approximately 50 pieces per hour, or in the case of the tandem fixture, about 80 pieces per hour. The saws last for about 6 to 8 hours depending upon the quality of the saw and the machinability of the material. All of the firms we saw had an automatic saw sharpening machine to keep these saws in condition. The finish obtained was fairly good, but by no means exceptional.

One interesting point worth noting was the way the spring nib was machined, in all the firms this was done by form filing in a milling machine; the "cutter" is mounted up as an ordinary milling cutter, but instead of being furnished with teeth is file cut on the cutting faces. The work is held in a shaped vice jaw and passed under this cutter before the pen is slotted, this process was universal in all the factories except one, and this firm used a home made form milling cutter with very fine helical teeth, actually the principle here was not very different, speeds were comparatively slow, but the production rate was in the region of 80 to 100 pieces per hour.

DRAWING PENS (Shaping).

When the pen points is machined, drilled and tapped, the nibs are shaped by hand, only in one case was there any attempt to machine the nibs to thickness, and even these were finally finished off with the file.

They are merely gripped by the shank in a suitable holder or hand vice and filed on a wood block in the vice, set to shape and passed on for hardening.

PENS (Hardening)

There was nothing revolutionary about the hardening processes, this is done in an open gas blowpipe flame at present, but was normally done in a gas fired muffle, this has been discontinued because of the fuel situation; hardening has to be done when gas is available, and as this is varying throughout the day, they do not light up the muffle, as by the time it has warmed up, the gas may go off, whereas by using the blowpipe they can be done singly when the fuel is available.

The pens are fitted into an iron holder, and hardened all over quenching in oil, whale oil was considered the best quenching medium, but as this has not been available for a long time, a substitute high flash point mineral oil is now used. These pens are then spring tempered by the same operator, the points being left hard.

There was no attempt at any of the firms at any sort of control of temperature and time of heating, but these hardening and tempering operatives were a very highly skilled, and the results they got were extremely good.

PEN HANDLES & FERRULES.

Handles were made from plastics in various colours and variety; one pen handle was made in rosewood (sample obtained). These were made very plainly and there was little or no attempt at ornamentation. The ferrules are made from brass, nickel silver or aluminium at present, but nickel silver is the material generally used in normal times.

DRAWING INSTRUMENTS (Finish, Assembly & Setting).

The factor which contributes most to the general high quality of German instruments lies in the finishing operations. So far as the non-ferrous parts are concerned, they are polished on soft cotton mops, and except for the skill of the operators, there is no revolutionary difference between our methods and those used in Germany.

The pens and steel parts are, however, worth special comment. There seemed to be a good deal of reluctance in explaining fully the procedure followed, but by summarising the information gathered from all these firms, the general scheme was as follows. For flat surfaces, the side of a large wooden cup wheel was used, this wheel was about 8"-10" diameter, and revolved at approximately 600 R.P.M. This speed varied a good deal in the various firms, but was approximately around this figure.

These wheels were faced with a home made mixture of glue and emery made up in rings and glued to the wheels, it is rather difficult to see the reason why ordinary cup grinding wheels could not be used, and we could get no satisfactory explanations, except that they were expensive and "not suitable".

It is possible that the secret of their finishes lies in this process, and samples of these wheels have been obtained.

Similar wooden grinding wheels are made of ordinary disc form and the abrasive applied to the out periphery.

The steel parts are applied to the face and edge of these wheels freehand, and it is here that the skill of the operator plays a very important part. Assume that we have an ordinary solid drawing pen similar to sample obtained (Gemunion), this is received by the grinder as from hardening. The whole of the outside flat surfaces are ground freehand on either the flat face of the cup wheel or the outside periphery of the disc wheel. The cutting faces are dressed with grease resembling tallow, and tallow was used until it ceased to become available, when a mineral grease of similar characteristics was substituted. The faces were finally finished off on leather faced wood laps using a white compound also greased (sample obtained).

The radiused ends of the nibs are also polished and ground on these wheels and finally the insides of the nibs are flattened off on a thin copper disc slightly rounded at the outer edges and dressed with a mixture of emery and grease. The whole of the above process is carried out without gauges and fixtures of any kind, and it was stated that a minimum training period of 3 years was required before these operators were efficient, and this impression was given us by all the manufacturers we saw, and there is no doubt whatever that these people had attained a remarkable proficiency and skill in this particular job.

The final assembly was done by men in all cases, they took boxes of components for a half set and assembled all the joints, checking all the time for parallelism, touching up the knuckles and removing small burrs etc, finally setting the pen points. An interesting point in this connection was that the pens were not tested with ink at all, apparently they know when the setting is correct and no test is necessary. A half set is assembled and adjusted in approximately 8 minutes, and then in some cases they are passed over to girls who wipe them up, and put them into their cases. There is not generally any final inspection of the instrument, except a check to see that the cases are filled etc, and inspection is carried out by the assemblers who employ a private selective assembly system of their own and reject parts which are defective and cannot be corrected, minor faults are put right as assembly proceeds.

The whole process of assembly and setting proceeds apparently without much difficulty, and a steady rate of output seems to be maintained at all times.

DRAWING INSTRUMENTS (Screws, Nuts etc.)

Many of the drawing instruments firms buy their screws from Switzerland, but there are one or two of the larger firms which make their own. These are made on small automatic screw making machines from mild steel, and are not to any extent novel or extremely fast; they turn out on an average about 80 to 100 parts per hour, mostly simple screws and nuts. All nuts are tapped in a tapping machine as a second operation, this machine is of standard type and simple holding devices for the nuts are employed.

SPRING BOWS.

The sample obtained is machined from solid and is fairly simple to make. A piece of flat steel is taken, the two outside limbs are form milled or machine filed, the hole drilled and c/bored for the centre screw they are then slit up the centre in similar manner to the pens. The hole for the handle is drilled and tapped, slots cut for the adjusting nut keys, hardened and spring tempered, the small keys for adjusting nut inserted and the steel part ground off ready for assembly. They are then assembled with either a divider, pen or pencil point as required.

CASE MAKING.

Most of the cases now being made are of the cheapest type. They consist of a pine top and bottom made very roughly in many cases outdoors by the people living in adjacent villages. The recesses for the instruments are routed out over a template, the method is similar to the one we use for cutting out centres of set squares, and is common to all the makers we saw. The woodworking machinery is of standard type, and no special apparatus is necessary.

They are lined by girls with a cheap felt which is all they can get at present, and covered with paper leatherette, all by hand. There are small glueing machines of the roller type, but these are quite usual. Cases are titled by a hand blocking press.

GENERAL CONCLUSIONS.

The factories we visited were fairly representative of the whole industry, the best were very good, ideally situated in country districts. The work turned out by these firms was of a very high quality. The best of these places were scrupulously clean, well laid out and well lighted.

It was stated that the atmosphere of the Bavarian Alps was very helpful where steel work is done, as work can be polished and left lying about with little risk of rusting or corrosion, and we saw plenty of evidence that this was the case. Rows of bright steel parts were exposed for fairly long periods without any visible rusting, and it was stated that this is one of the reasons for the location of

many of these factories in this district.

By contrast we saw a factory near Nurenburg in an old house, and conditions here were very bad, in fact in England they would not have been tolerated. This firm made only the very cheapest form of instruments from zinc strip, and both quality and finish were very poor.

Wherever we went we were struck by the application and dexterity of the average German operative, whether male or female. They attain an extremely high degree of dexterity and a very high rate of production. It seems that the reason for this lies in the fact that the majority of these firms are the centres of village communities of approximately 400 to 600 people, and they are dependent for their living on either the factory or agriculture. The factory provides a slightly higher standard of living than does agriculture, and there is no competition from other factories for their services. This coupled with the fact that the average German does not revolt against discipline, and in fact it has been instilled into them for a number of years may also account for part of their industry.

In fact, beyond the high rate of production attained by the polishing and grinding operatives, the conclusion we arrived at was that although methods did not differ materially from our own, and in some cases were inferior to modern British practice, the rate of production of the average German was at least 25% better than the average British operator, and in many cases more than 50% better.

## PLANIMETERS, INTEGRATORS & PANTAGRAPHS.

A. Ott.
Reiffler.
Meyr & Hormann.

GENERAL MACHINING (Planimeters).

There are three firms which we saw making planimeters, but it was only at Messrs. Ott that they were being made exclusively. The two smaller firms were making only the simple fixed scale and sliding bar types. This description will only deal with the products we saw at Messrs. Ott as there was nothing really outstanding at the other two firms so far as planimeters were concerned.

The carriages are generally made from aluminium castings, but in some cases they are machined from solid Duralumin flat section bar. This is mainly due to the fact that Messrs. Ott have no foundry of their own and when there are only a few required, they find this the most economical method. Occasionally they make some carriages where extra weight is desirable in "Hard brass castings", this material appears to be equivalent to our gunmetal although rather lighter in colour. The tracer bars are of brass square section tubing made on very similar lines to our own. All the small parts are of mild steel with the exception of course of the roller disc and spindle, which are of silver steel (or cast steel) hardened but not tempered. They apparently aim at extreme hardness on both these components, the female centres which the recording disc revolves in are slightly tempered to a light straw.

All components are finished and nickel plated or sprayed as required, and are not assembled at all prior to the final calibration and adjustment.

We were rather surprised to see the dividing machine for the tracer-bars, this was a machine similar to a thermo dividing machine, but on a larger scale, and bars were divided by hand, one at a time. The celluloid recording wheel drum was also divided on a special dividing machine, but this one was automatic. There did not appear to be much saving in time, as the operator stood by the machine while it was working, but this can be understood, as there are only 100 divisions round the drum, and the time for dividing is in the neighbourhood of 2 minutes each. The figures are engraved on both the bar and drum.

The most interesting and instructive points we observed were in the assembly and calibration, and these will be fully described under separate headings.

ASSEMBLY CARRIAGE & TRACER.

The components as already described are finished ready for assembly, the bar is first of all fitted to the square hole in the carriage, and the adjustment checked to see that there is sufficient movement to get the pivots parallel to the line joining the tracer point and the pole centre in the carriage. Incidentally all sliding bar planimeters are provided with a parallelism adjustment. There is no check at this stage, and all that is necessary is to see that the adjustment is adequate.

The centres are then fitted, and it was emphasized to us that it was important that they should be softer than the male centres on the recording wheel, and as previously mentioned, these centres are dead hard and the female centres in the carriage itself are tempered to a light straw.

The remaining parts are then assembled including the pole arm, and checking rule. The recording wheel is then dealt with, the spindle recording disc and celluloid drum are mounted, and the points touched up in the lathe with an arkansas stone by hand. I watched this process with considerable interest, and was much impressed with the beautiful finish obtained, and this was considered to be one of the most important factors in obtaining the high order of accuracy which this firm attains. After the recording disc and drum are mounted, the "tread" is form ground to toroid shape on a small grinding machine, this machine was made on the premises, and is quite a simple piece of apparatus. The wheel is trimmed frequently with a diamond former which is fed straight into the grinding wheel, the recording wheel is then ground to plus .0005" (approx) of finished diameter. The recording wheel assembly is then taken to another machine, and the "tread" is put on. This is another of the really important differences in the practice of German firms and our own, and in all the three firms where planimeters were being made, the method to be described was essentially the same, although the apparatus was slightly different in design.

The recording wheel is fitted into a reciprocating frame which moves in a direction parallel to the axis of rotation of the recording wheel, at a rate of about 100 oscillations per minute; the length of the stroke is about 2½" to 3". A flat piece of Arkansas or similar fine abrasive oilstone is in contact with the "tread" of the wheel, and at the end of each stroke is moved automatically in a direction at right angles to the axis of rotation by about .005" per stroke, thus rolling the recording wheel over its surface. The carriage is pivoted and weighted so that a pressure of about 1½ to 2 ozs is applied to the wheel as it rests on the stone.

This machine is quite simple in construction and was made on the premises. The time taken to process one wheel is about 3 minutes. It was only at Messrs. Otts that we were shown this machine working, and its importance emphasized, at the other two firms they were not at all anxious to gratify our curiosity. First of all they "didn't understand", then the machine wasn't available, and then it wasn't working, and finally it wasn't very important anyway. However, we drew our own conclusions, and fortunately we had just come from Otts, and we knew what we were looking for.

A further point of interest was in the test for parallelism applied independently to the recording roller. This struck me as being so simple and fundamental that I feel that it should have occurred to us.

The apparatus consisted of a straight edge about $2\frac{1}{2}$" wide x $\frac{3}{8}$" thick, and about 2 ft long, covered with matted celluloid or similar substance; some of these were covered with paper. A Vee shaped groove runs along the face close to one edge. A special carriage is arranged to run in this groove on a triangular strip.

The recording wheel is mounted in this frame and run along in a direction parallel to its axis of rotation and the wheel must not turn more than 1/1000 of a turn in about a 20" run. The apparatus can be easily checked by reversing the recording wheel end for end in the frame, when any errors in the parallelism of the apparatus will become apparent by a rotation in the opposite direction of the recording wheel as it is turned over.

When the recording wheel has been ground and tested, it is mounted in its own carriage and the instrument is set for parallelism in A & B positions, using the adjustment provided. The parallelism is checked at two positions on the tracer arm for sliding bar planimeters, and adjusted by either setting the tracer arm if it is not quite straight or bending over the tracing point. This may sound a bit brutal, but in fact the actual amount of bending in either case is extremely small.

After this the operator proceeds to calibrate each scale, and the method used is almost identical with our own, a standard checking rule is used, and several readings are taken of each bar setting required. The only difference being that a checking rule with a standard needle point is used. The constants are then obtained by the interior pole method similarly to our own except again a standard needle point is used, and the pole block rests in a groove slightly one side of the needle point. It struck me as being very strange to come to a foreign country to see operators doing exactly the same as we have been doing here.

Almost one could imagine in this adjusting process our own planimeters calibrating equipment and tools as having been brought out here; even the operators themselves were of the same type; and in this case by what we saw, the time taken for this process compared with our own.

The checking rules are calibrated with the planimeters they are to accompany, and are numbered serially. The value of the area of the circle is entered on a chart provided with the planimeter, and is not engraved on the checking rule.

The whole of the batch assembly and adjusting is undertaken by one man, and he sees the job right through. They appear to be issued in lots of about 25 instruments, and it was stated that Messrs. Ott had found this to be the most satisfactory method, and in normal times had as many as 10 men working on assembling and adjusting batches of planimeters alone.

A test report is made out for each instrument and goes with it for final inspection. This inspection is only of a very cursory nature and consists mainly of wiping up the instrument, writing out the calibration chart, and putting the planimeter and its accessories into the case. Here again we have the combined assembly and inspection routine, working apparently quite well, as the people who assemble and calibrate have a fairly free hand as to what shall or shall not be used, but we saw the components as delivered to the calibrating department, and there appeared to be very little doubt as to their high quality and finish.

We were given to understand however, that a fairly stringent component inspection was operating in another factory where most of the turning was done, and small screws etc. made. We inspected this component factory, and more will be said about this later.

This firm was also making a range of "rule" planimeters, and it was definitely stated that for the evaluation of strip charts this type was by far the most accurate; the planimeter was always arranged to run on the paper or celluloid surface of the rule if this was at all possible, and in most cases this method was used. The system of calibration, assembly and adjustment was individual as previously indicated.

We had a long discussion as to the relative merits of the pole waggon and the rail type of instrument for strip charts, and Mr. Ott was most emphatic as to the advantage of the rail type. I raised the point that Coradi of Zurich seemed to be firmly attached to the parallel rolling type, and while he agreed that this firm was certainly a good one, he could not understand their adherence to this design.

The question of long strip charts was also discussed, and he gave it as his opinion that far greater accuracy could be obtained by dividing the chart into manageable lengths and evaluation each length separately with a rail type of instrument as far greater accuracy could be obtained by this means, especially as these long charts never had a true base to work from, and as they were unevenly exposed to the weather, extremes of heat and cold, and all kinds of corrosive atmospheres, the linear dimension on the chart would have to be compensated for in any case, as he had personally known of shrinking and stretching taking place by an amount equal to .5 cm per metre over a 2 metre length. This is a point worth noting in the instructions which will have to be issued in connection with continuous strip planimeters.

There were also on view a larger range of circular chart planimeters and radial planimeters. These differed very little from our own, in fact they are to all intents the same, even the method of producting the slots, was identical with our own.

We also had a long discussion about integrators. Mr. Ott was aware that we were making integrators, and I am quite sure that he was quite pleased to hear that a British firm had decided to tackle this job. We discussed the relative merits of the "geared" type over the "lever" type which Otts specialize in, and while he admitted that the accuracy of the gearing and centering was of such paramount importance that they had decided long ago to concentrate on the lever type, due mainly to the difficulties of producing gearing of a sufficiently high order of accuracy. It seemed to me rather strange that a firm of this standing should have experienced trouble in this direction.

The strangest thing was the fact that he advised me to try an experimental integrator of the lever type and stated that he was sure that this was the best system, that we should undoubtedly come to the same conclusion.

We did just touch upon the parallel rolling type integrator of Coradi and he said it was not possible to attain any great degree of accuracy with this type, due to the fact that the instrument cannot be relied upon to follow a straight path in all circumstances, a point with which I am in full agreement.

This firm have a special grinding machine to produce their rails on; it is of straight forward construction, with a very long bed, and can accommodate rails up to 72" in length. Incidentally it is only rarely that they are called upon to supply rails as long as this. They are made from mild steel flat bar. Surface ground all over, first of all, and then the groove is ground in on this special machine. The production of these rails to within the required accuracy did not present any serious difficulty.

There were two most interesting instruments in course of development which can only be mentioned. One of these is a differential analyser, this machine is mechanically operated, and consists of 5 similar units linked together by synchronous motors from a huge central switchboard. Much as I would have liked to spend a few weeks on it, the whole apparatus was far too complex to attempt an explanation in our very cursory inspection of the machine.

The other apparatus was an integrator of very complicated construction, which consisted of any number (up to 8) of linked integrator frames connected together by means of links and gearing, which would give several different functions of a harmonic or similar curve. Both these instruments were being made under the auspicies of a Dr. Walther of Darmstadt Technical College, and several of the students were working under instructions from this faculty. Here again it was not possible in the very short time we had at our disposal to go fully into this instrument, considering that development had been proceeding for some years, and was not yet complete. Nothing has as yet been published on these two instruments, but when the information has been collected and printed, I have been promised full details of the apparatus. It was, however, indicated that in any case, this would not be available for a few years to come.

The assembly and adjustment of integrators follows similar lines to that of the planimeter, and a full test report giving all the results as adjustment progresses is prepared and kept as a record. It must be mentioned here that a new type of integrator has been developed, and although we did not see one, I had a set of photographs of this instrument given me. This type of instrument gives the area, static moment, and moment of inertia of a plane figure with only a simple multiplier.

The small component factory was visited, and there were several automatic machines running on small parts. Most of the components were made on Pittler machines, and it was rather surprising to me to see the number of these machines in use. We hardly saw a Capstan machine of conventional British design.

Inspection at the component factory was very much in evidence compared with all the other factories we visited, but this is understandable as the components produced in many cases cannot be rectified on assembly as can drawing instrument parts.

The factory was extremely clean and tidy, and here again we saw the same application to work as we saw in other factories in Germany. This firm is also making a large range of hydrometrical instruments, current meters, tide gauges, rain gauges etc, but this part of the business was not explored at all.

PANTAGRAPHS.

Messrs. Ott are making two types of pantagraphs at present, and we saw both. Normally there is a fairly extensive selection, but the types have been drastically reduced during the war.

The suspended type is of normal construction, and is the same as has been made for the last 20-30 years. The bars are tubular brass, divided decimally and nickel plated, reading by vernier to 1/1000 of the divided length, pencil boxes etc. are of normal construction, and although very well made and fitted, possess no novel features. The centres are of hardened steel running in female cones throughout, except for the main centre which is a ball bearing fitted into the base of the pantagraph. The whole of this instrument is of really first class construction and pivots, pencil boxes etc, are fitted with the same care and accuracy as the various planimeters and similar instruments, and comparing these pantagraphs to our own type, quite apart from the differences in design already noted, this high standard is responsible for the extremely light and free movement which these instruments possess.

These pantagraphs are also calibrated for ratios if required, but we were informed that the decimally divided type was the one normally supplied. This instrument is scheduled for re-design in the near future, but changes were not likely to be revolutionary, and would apply more to refinements and accessories than the instrument itself.

There is also being made a simple pantagraph with pearwood bars, and although this does not compare with the one described, it is quite a good job and embodies the suspension principle.

GENERAL.

One point of interest in connection with this firm, was that of all the firms we saw in Germany, this was the only firm with a specific apprentice training scheme in operation. A special shop is set aside for this purpose with instructors available for the various branches of the firm. Theoretical training is also part of the scheme. This department is extremely well equipped, and small batches of components are made which are subsequently used. The equipment consists of about a dozen machines of similar types to those normally in use in the factory. There is also a good selection of testing and gauging equipment for the sole use of this department. Mr. Ott told us that their firm had always considered itself to be one of the most highly specialized firms in Germany, if not in Europe, and had always worked very closely with the Engineering and Technical Colleges and other Institutions,and while we were there, several students from Darmstadt Technical School were working on some special apparatus, and were allowed and encouraged to use all the resources of this firm.

Altogether this visit was one of the most pleasant and productive of any I have had anywhere, at any time.

The factory itself was as usual very clean and tidy, proper routine for ordering and costing was insisted upon; all components and instruments were rigidly delivered to Stores when finished, and the system of routing employed was similar to our own. This was the only firm we saw in Germany where procedure seemed to be insisted upon to any great extent, but as it was explained to us, this firm makes such a large variety of products, many componenets of which are common to several instruments, that some sort of system is not only desirable, but absolutely essential.

## SLIDE RULES AND MATHEMATICAL SCALES.

Albert Nestler.
A. W. Faber.

We inspected two firms making slide rules and mathematical scales. The processes of preparing were practically identical at both firms, and will be briefly described. The dividing and figuring were very different, however, and will be dealt with separately.

All scales and slide rules are cut from planks which are seasoned for some years, preferably 10 to 15. The woods used are at the moment rather mixed, but normally mahogany, boxwood and pearwood are considered to be satisfactory. At the moment a native wood known as "ESCHEN" (German) is used, Up to the present I have not been able to get at its English equivalent. This wood is considered to be fairly good substitute. These blanks are thicknessed on a standard thicknesser and stored, preferably for at least 6 months. Steel springs are sandwiched between two blanks which are glued together to form the base of the rule. The guides and slides are also prepared and thicknessed and left for seasoning for 6 months. Metal inserts are then let into the slide and guides, and these are faced with celluloid where required, put into large presses about 30 in a press, and stored for a further 6 months. At the end of this period they are taken out, and the slide machined to width and tongued and fitted tightly into the stock. The faces of the rule and slide are then scraped and prepared for dividing; there is a battery of automatic sand papering machines specially designed for scales. These are quite simple in principle, and consist of a reciprocating arm which carries a small sandpapering block. This is lightly sprung down on to the face of the scale and sandpaper from a narrow roll is slowly fed over the block. None of these machines were working, but we are informed that one girl could look after a battery of about 12 machines. Most of the operations described above were common to both firms but the methods of dividing were totally different in the two firms, and will be described separately.

The machines used by Albert Nestler are multiple logarithmic dividing machines, and multiple straight line machines for evenly dividing scales. These machines were all made on the premises, and this firm had an extensive and well equipped heavy engineering shop. This department, however, was completely destroyed in an air raid, but is being put into commission again in another building.

These machines are of fairly straight forward design, they consist of a long table about 10 or 12 feet long, over which are mounted a series of cutting heads, operated by shafts running parallel with the bed of the machine by menas of links and levers. The table is moved by a heavy lead screw (about 3" dia) giving about 24" of movement to the bed.

This is operated through gearing, by a spiral logarithmic drum driven by a reciprocating Pawl mechanism. Change gears are provided to enable the log scale to be increased or reduced in length. The length of lines we were given to understand was controlled by a somewhat similar notched spiral drum, fitted into the machine. Unfortunately we would not see this, as it would have meant stripping the machine down. About 50 slide rules could be divided at once on the machine, and there were several available.

The straight scale machines were of similar construction, except that the mechanism for moving the table was much simpler as they were for evenly divided scales. We deduced, from the speed that these machines were run at, that a batch of 50 completely divided slide rules could be produced in 3 hours, roughly 4 minutes per rule exclusive of setting time.

In addition to the above machines, there was a multiple circular dividing machine which worked on similar lines, except that there was a long shaft operating on the worm and wheel principle, which revolved about 8 or 10 small circular tables with cutting frames mounted over each table. These were used for dividing celluloid protractors, and although the rate of output was very high, there was nothing really remarkable about them.

Cutting knives of high speed steel were used on all these machines and they were of the usual design which we have used ourselves for a number of years.

Messrs. A.W. Faber used a totally different system and except for a single straight line dividing machine which was used for special and working standards, all their "dividing" was done by a heat embossing method. First of all a master of "matrix" is prepared by taking a brass bar of rectangular section about $1\frac{1}{2}$" x 1", and as long as the scale which is to be divided. Across this block narrow slits are cut corresponding to the intervals of the scale, about .07" deep and .003" wide. Thin steel strips are inserted into these slits so that they project about .03" above the face of the block. The whole block is then placed on a surface grinder, and the projecting edges of the steel strips are all ground over the tops so that they all lie in the same plane. Holes are drilled where the figures are to come, and small figure punches are inserted.

This "matrix" is mounted in a machine very similar to a lever hand printing press, and heated to a temperature of approx. 75°C by a water circulating system. It is then lowered on to the face of the rule and held there under slight pressure for approx 5-10 seconds depending on the amount of dividing on the scale. In this manner the whole face of a slide rule can be divided, and figured in a few minutes.

The "matrices" are of course expensive to produce, but as we could easily see, except for accidental damage, they are practically indestructible, and the matrix for a single cycle 10" log scale would take about 50 hours to produce.

The engineers scales were also made in a similar manner, but in this case a semi-automatic dividing machine produced the masters slotted ready to receive the steel strips.

The dividing is then filled in red or black as required, the faces papered off and finished; the slide fitted and made to work easily, cursor fitted and the instrument inspected and packed into its case.

The method of producing the cursors was by grinding in a special machine about a dozen being done at a time. This machine is a simple reciprocating table on which the cursor glasses are mounted, with weighted arms carrying thin steel blades resting on the surface of the glass. A mixture of fine abrasive ("Sandstone") and water is dropped on to the surface and ground for about 5 minutes. The glass is then taken off, wiped and passed on to be fitted into its frame.

GENERAL CONCLUSIONS.

The foregoing remarks would not be complete without some reference to conditions in Germany today, and their influence on the production of the country. It must be understood that the people are living and working under martial law, both individuals and firms are severely restricted. Materials are extremely difficult to get as many of these firms have had the opportunity during the war of obtaining all their requirements easily from both the German occupied countries in Europe, and many of the neutrals as well. The position is now completely altered and materials are only available locally from that part of Germany controlled by the appropriate occupying power.

Transactions with neutral countries are impossible, except for work done exclusively for the occupying power.

Fuel and food are extremely short, and many firms were not able to work for more than 3 or 4 days per week in the winter.

It is extremely difficult to give an opinion about the attitude of the people, it varies so much in the different parts of the country we saw.

On the whole the people seem to be trying to make the best of a very bad job, but in the absence of any coherent form of government and leadership, the life and conditions of the civilian population are extremely difficult.

The damage to industrial plant in all the manufacturing towns we saw was enormous. Transport and public utility services are severely disorganised, and the housing problem is appalling. Many thousands of people are wandering about Germany, apparently aimlessly, living as best they can. The damage in many of the large towns is devastating, and it will be many years before Germany can regain the strong position she held before and during the early part of the war.

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